



# 2100AI PCIe NVMe NAND Flash SSD

**MTFDHBL064, MTFDHBL128, MTFDHBL256, MTFDHBL512, MTFDHBM1T0,  
MTFDHBK128, MTFDHBK256, MTFDHBK512, MTFDHBK1T0**

## Features

- Micron® 3D TLC NAND Flash
- PCIe Express base specification Rev 3.0
  - Gen3 x4 lanes
  - Backward Compatibility
- NVMe Express Rev 1.3c compliant
  - Number of namespaces supported: Up to 4
  - Round robin arbitration: weighted
  - Autonomous power state transitions
  - Host memory buffer (HMB)
  - Boot partitions and RPMB
  - End-to-end data protection
- Retention JESD47 compliant:
  - 5 years @55°C at 10% of TBW
  - 1 year @55°C at max TBW
- Package compliance:
  - RoHS certification
  - BGA, MSL3
- Capacity (unformatted)<sup>1</sup>: 64GB, 128GB, 256GB, 512GB, 1024GB
- Physical capacity management (SLC mode)
- Endurance: Total bytes written (TBW)
  - Up to 480TB for 1024GB
- Security
  - TCG/Opal 2.0 compliant self-encrypting drive (SED)
  - Hardware-based AES-256 encryption engine
  - Digitally signed firmware
  - Firmware secure boot
- Self-monitoring, analysis, and reporting technology (SMART) command set
- Power loss protection for data-at-rest
- Performance<sup>2</sup>
  - Sequential 128KB READ: Up to 2000 MB/s
  - Sequential 128KB WRITE: Up to 1800 MB/s
  - Random 4KB READ: Up to 200,000 IOPS
  - Random 4KB WRITE: Up to 130,000 IOPS
- Latency<sup>3</sup>
  - Read (TYP): 85µs
  - Write (TYP): 40µs
- Host-controlled thermal management
- Low power consumption
  - Sleep: 3mW/5mW (PS4 & L1.2) BGA/M.2

- Reliability
  - MTTF: 3 million hours<sup>4</sup>
  - Static and dynamic wear leveling
  - Uncorrectable bit error rate (UBER): <1 sector per 10<sup>16</sup> bits read
- Micron redundant array of independent NAND (RAIN) technology

## Options

## Marking

- |                                      |     |
|--------------------------------------|-----|
| • Form Factor                        |     |
| – BGA type 1620, 16mm x 20mm x 1.2mm | BL  |
| – BGA type 1620, 16mm x 20mm x 1.6mm | BM  |
| – M.2 type 2230, 22mm x 30mm         | BK  |
| • Density                            |     |
| – 64GB                               |     |
| – 128GB                              | 128 |
| – 256GB                              | 256 |
| – 512GB                              | 512 |
| – 1TB                                | 1T0 |
| • Product Family                     |     |
| – 2100AI                             | DP  |
| • BOM                                |     |
| – 1 <sup>st</sup> Generation         | 1   |
| – Engineering Samples                | A   |
| • Operating Temperature <sup>5</sup> |     |
| – Grade 3 extended (–40°C to +95°C)  | IT  |
| • Customer Designator                |     |
| – Standard                           | YY  |

- Notes:**
1. User capacity: 1GB = 1 billion bytes.
  2. Typical I/O performance numbers as measured fresh-out-of-box (FOB) with HMB enabled.
  3. 4KB, queue depth 1 transfers used for READ/WRITE latency values.
  4. Mean Time To Failure (MTTF) based on population statistics not relevant to individual units.
  5. Case surface temperature.

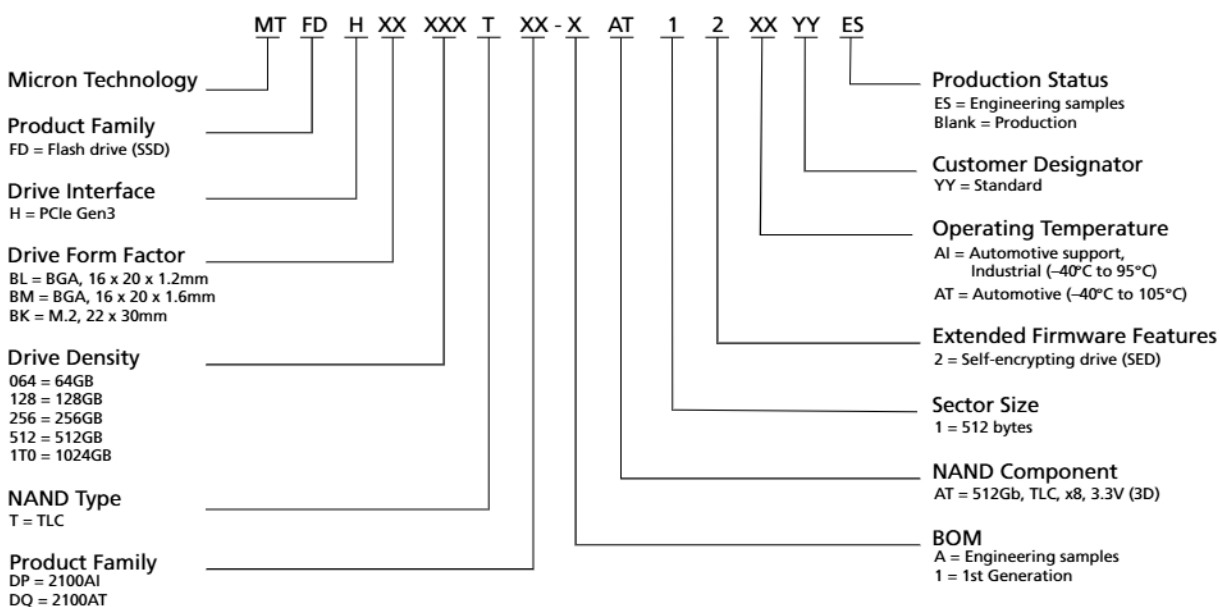


## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Features

### Part Number Ordering

Verify valid part numbers by using Micron's part catalog search at [www.micron.com](http://www.micron.com). To compare features and specifications by device type, visit [www.micron.com/products](http://www.micron.com/products). Contact the factory for devices not found.

**Figure 1: Part Number Ordering Information**



**Table 1: Part Number Ordering Information**

| Base Part Number        | Density | Package                                  |
|-------------------------|---------|------------------------------------------|
| MTFDHBL064TDP-1AT12AIYY | 64GB    | BGA type 1620, 16mm x 20mm x 1.2mm       |
| MTFDHBL128TDP-1AT12AIYY | 128GB   | BGA type 1620, 16mm x 20mm x 1.2mm       |
| MTFDHBL256TDP-1AT12AIYY | 256GB   | BGA type 1620, 16mm x 20mm x 1.2mm       |
| MTFDHBL512TDP-1AT12AIYY | 512GB   | BGA type 1620, 16mm x 20mm x 1.2mm       |
| MTFDHBM1T0TDP-1AT12AIYY | 1TB     | BGA type 1620, 16mm x 20mm x 1.6mm       |
| MTFDHBK128TDP-1AT12AIYY | 128GB   | M.2 Type 2230 M-key, 22mm x 30mm x 2.0mm |
| MTFDHBK256TDP-1AT12AIYY | 256GB   | M.2 Type 2230 M-key, 22mm x 30mm x 2.0mm |
| MTFDHBK512TDP-1AT12AIYY | 512GB   | M.2 Type 2230 M-key, 22mm x 30mm x 2.0mm |
| MTFDHBK1T0TDP-1AT12AIYY | 1TB     | M.2 Type 2230 M-key, 22mm x 30mm x 2.4mm |



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## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD General Description

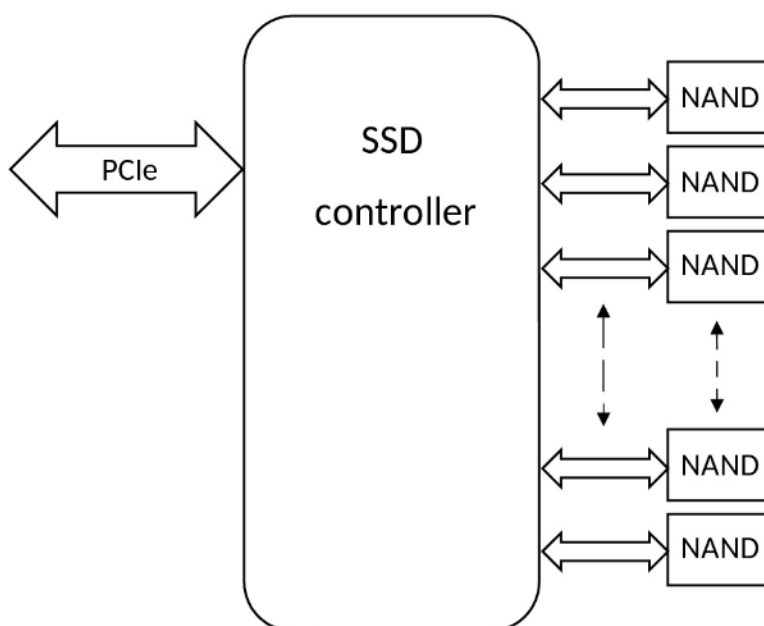
### General Description

Micron's 2100AI solid state drive (SSD) uses a single-chip controller with a PCIe Gen3 interface connecting up to four PCIe lanes to Micron's 3D TLC NAND Flash.

The SSD is designed to use the PCIe interface efficiently during both READs and WRITES while delivering bandwidth-focused, low latency performance through the innovative Nonvolatile Memory Express protocol. SSD technology enables enhanced boot times, faster application load times, reduced power consumption, and extended reliability.

The 2100AI is ideally suited for industrial applications, which require mass storage in a very small footprint.

**Figure 2: Functional Block Diagram**







## Performance

Measured performance can vary for a number of reasons. The major factors affecting drive performance are the capacity of the drive and the interface of the host. Additionally, overall system performance can affect the measured drive performance. When comparing drives, it is recommended that all system variables are the same, and only the drive being tested varies.

Performance numbers vary depending on the host system configuration.

For SSDs designed for the client and cloud computing markets, Micron specifies performance in fresh-out-of-box (FOB) state and steady state. Data throughput measured in steady state may be lower than FOB state, depending on the nature of the data workload.

For a description of these performance states and of Micron's best practices for performance measurement, refer to Micron's technical marketing brief Best Practices for SSD Performance Measurement.

**Table 2: Drive Performance With/Without HMB Enabled – Fresh Out of Box**

| Parameter                         | 64GB    |        | 128GB   |        | 256GB   |        | 512GB   |        | 1024GB  |        | Unit |
|-----------------------------------|---------|--------|---------|--------|---------|--------|---------|--------|---------|--------|------|
|                                   | HMB Off | HMB On | HMB Off | HMB On | HMB Off | HMB On | HMB Off | HMB On | HMB Off | HMB On |      |
| Sequential read (128KB transfer)  | 550     | 550    | 1100    | 1100   | 2000    | 2000   | 2000    | 2000   | 2000    | 2000   | MB/s |
| Sequential write (128KB transfer) | 250     | 250    | 500     | 500    | 1000    | 1000   | 1700    | 1700   | 1800    | 1800   | MB/s |
| Random read (4KB transfer)        | 12K     | 25K    | 20K     | 50K    | 38K     | 100K   | 65K     | 170K   | 105K    | 200K   | IOPS |
| Random write (4KB transfer)       | 40K     | 50K    | 60K     | 85K    | 80K     | 110K   | 90K     | 120K   | 100K    | 130K   | IOPS |
| READ latency (TYP)                | 85      | 85     | 85      | 85     | 85      | 85     | 85      | 85     | 85      | 85     | μs   |
| WRITE latency (TYP)               | 40      | 40     | 40      | 40     | 40      | 40     | 40      | 40     | 40      | 40     | μs   |

- Notes:
1. Performance values measured in fresh-out-of-box (FOB) state using FIO with a queue depth of 32.
  2. Drive write cache enabled.
  3. NVMe power state 0.
  4. 4KB transfers with a queue depth of 1 are used to measure READ/WRITE latency values.
  5. 4KB transfers can be further improved with the support of HMB by the host.
  6. System variations will affect measured results.



## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Logical Block Address Configuration

### Logical Block Address Configuration

The drive is set to report the number of logical block addresses (LBA) that will ensure sufficient storage space for the specified capacity. Standard LBA settings (100% TLC), based on the IDEMA standard (LBA1-03), are shown below.

**Table 3: Standard LBA Settings (100% TLC)**

| Capacity | Total 512 - Byte LBA |             | Max 512 - Byte LBA |             |
|----------|----------------------|-------------|--------------------|-------------|
|          | Decimal              | Hexadecimal | Decimal            | Hexadecimal |
| 64GB     | 125,045,424          | 7740AB0     | 125,045,423        | 7740AAF     |
| 128GB    | 250,069,680          | EE7C2B0     | 250,069,679        | EE7C2AF     |
| 256GB    | 500,118,192          | 1DCF32B0    | 500,118,191        | 1DCF32AF    |
| 512GB    | 1,000,215,216        | 3B9E12B0    | 1,000,215,215      | 3B9E12AF    |
| 1024GB   | 2,000,409,264        | 773BD2B0    | 2,000,409,265      | 773BD2AF    |

**Note:** Look at Physical Capacity Management (page 9) Section for more options related to SLC Vs. TLC configurations



## Reliability

Micron's SSDs incorporate advanced technology for defect and error management. We use various combinations of hardware-based error correction algorithms and firmware-based static and dynamic wear-leveling algorithms.

Over the life of the SSD, uncorrectable errors may occur. An uncorrectable error is defined as data that is reported as successfully programmed to the SSD but when it is read out of the SSD, the data differs from what was programmed.

**Table 4: Uncorrectable Bit Error Rate**

| Uncorrectable Bit Error Rate      | Operation |
|-----------------------------------|-----------|
| <1 sector per $10^{16}$ bits read | READ      |

## Mean Time To Failure

Mean time to failure (MTTF) for the SSD can be predicted based on the component reliability data using the methods referenced in the Telcordia SR-332 reliability prediction procedures for electronic equipment.

**Table 5: MTTF**

| Capacity       | MTTF (Operating Hours) |
|----------------|------------------------|
| All capacities | 3 million              |

Note: 1. The mean time to failure (MTTF) reported in the above table is based on population statistics. Therefore, it is not relevant to individual unit.



## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Reliability

### Endurance

Endurance for the SSD can be predicted based on the usage conditions applied to the device. The table shows the minimum drive lifetime for each SSD capacity based on predefined usage conditions noted below.

**Table 6: Total Bytes Written**

| Capacity | Total Bytes Written |
|----------|---------------------|
| 64GB     | 30TB                |
| 128GB    | 60TB                |
| 256GB    | 120TB               |
| 512GB    | 240TB               |
| 1024GB   | 480TB               |

- Notes:
1. Total bytes written validated with the drive 90% full.
  2. SSD volatile write cache is enabled.
  3. Access patterns used during reliability testing are 25% sequential and 75% random and consist of the following: 1% are 512B; 44% are 4 KiB; 35% are 64 KiB; and 20% are 128 KiB.
  4. Host workload parameters, including write cache settings, I/O alignment, transfer sizes, randomness, and percent full, that are substantially different than the described notes may result in varied endurance results.
  5. GB/day can be calculated by dividing the total bytes written value by (365 × number of years). For example: 100TB/5 years/365 days = 54GB/day for 5 years.





## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Physical Capacity Management

### Physical Capacity Management

At least one of the user configurable namespaces (up to four) can be configured in “SLC mode” to meet the most demanding endurance requirements. This is the case of write intensive applications or applications requiring long retention with limited writes. SLC mode also ensures higher performance.

Micron has defined the vendor specific Physical Capacity Management command to perform physical space configuration. The Physical Capacity Management command is a vendor-specific NVMe Admin command. This command provides operations which are outside the scope of the NVMe standard and which, to date, have been implemented by multiple companies in vendor-specific manners. This command makes use of concepts defined in the NVMe standard.

Search for *TN-FD-49: 2100AI/AT Physical Capacity Management* Technical Note at <http://www.micron.com>. Alternatively, consult your sales representative for more information.

### Endurance

**Table 7: Bytes Written**

| SLC Mode<br>Size [%] | Total Bytes Written (in Terabytes) |       |       |       |        |
|----------------------|------------------------------------|-------|-------|-------|--------|
|                      | 64GB                               | 128GB | 256GB | 512GB | 1024GB |
| 0% (Default)         | 30                                 | 60    | 120   | 240   | 480    |
| 10%                  | 77                                 | 154   | 308   | 616   | 1232   |
| 20%                  | 124                                | 248   | 496   | 992   | 1984   |
| 30%                  | 171                                | 342   | 684   | 1368  | 2736   |
| 40%                  | 218                                | 436   | 872   | 1744  | 3488   |
| 50%                  | 265                                | 530   | 1060  | 2120  | 4240   |
| 100%                 | 500                                | 1000  | 2000  | 4000  | 8000   |



## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Physical Capacity Management

### Logical Block Address Configuration

**Table 8: SLC LBA Settings**

| SLC Mode<br>Size [%] | Total 512 - Byte LBA |            |             |             |             |
|----------------------|----------------------|------------|-------------|-------------|-------------|
|                      | 64GB                 | 128GB      | 256GB       | 512GB       | 1024GB      |
| 0% (Default)         | 0                    | 0          | 0           | 0           | 0           |
| 10%                  | 4,182,136            | 8,343,096  | 16,684,564  | 33,347,950  | 66,694,264  |
| 20%                  | 8,343,096            | 16,684,564 | 33,347,950  | 66,694,264  | 133,367,352 |
| 30%                  | 12,523,596           | 25,026,024 | 50,030,878  | 100,040,578 | 200,059,980 |
| 40%                  | 16,684,564           | 33,347,950 | 66,694,264  | 133,367,352 | 266,733,076 |
| 50%                  | 20,845,522           | 41,689,410 | 83,357,650  | 166,713,666 | 333,406,162 |
| 100%                 | 41,689,410           | 83,357,650 | 166,713,666 | 333,406,162 | 666,810,690 |

**Table 9: TLC LBA Settings**

| SLC Mode<br>Size [%] | Total 512 - Byte LBA |             |             |               |               |
|----------------------|----------------------|-------------|-------------|---------------|---------------|
|                      | 64GB                 | 128GB       | 256GB       | 512GB         | 1024GB        |
| 0% (Default)         | 125,045,424          | 250,069,680 | 500,118,192 | 1,000,215,216 | 2,000,409,264 |
| 10%                  | 112,543,006          | 225,064,834 | 450,108,492 | 900,195,816   | 1,800,370,462 |
| 20%                  | 100,040,578          | 200,059,980 | 400,098,792 | 800,176,414   | 1,600,331,650 |
| 30%                  | 87,538,152           | 175,055,134 | 350,089,090 | 700,157,004   | 1,400,292,840 |
| 40%                  | 75,035,724           | 150,050,280 | 300,079,390 | 600,137,602   | 1,200,254,028 |
| 50%                  | 62,533,296           | 125,045,424 | 250,069,680 | 500,118,192   | 1,000,215,216 |
| 100%                 | 0                    | 0           | 0           | 0             | 0             |

**Table 10: Total LBA Settings**

| SLC Mode<br>Size [%] | Total 512 - Byte LBA |             |             |               |               |
|----------------------|----------------------|-------------|-------------|---------------|---------------|
|                      | 64GB                 | 128GB       | 256GB       | 512GB         | 1024GB        |
| 0% (Default)         | 125,045,424          | 250,069,680 | 500,118,192 | 1,000,215,216 | 2,000,409,264 |
| 10%                  | 116,725,142          | 233,407,930 | 466,793,056 | 933,543,766   | 1,867,064,726 |
| 20%                  | 108,383,674          | 216,744,544 | 433,446,742 | 866,870,678   | 1,733,699,002 |
| 30%                  | 100,061,748          | 200,081,158 | 400,119,968 | 800,197,582   | 1,600,352,820 |
| 40%                  | 91,720,288           | 183,398,230 | 366,773,654 | 733,504,954   | 1,466,987,104 |
| 50%                  | 83,378,818           | 166,734,834 | 333,427,330 | 666,831,858   | 1,333,621,378 |
| 100%                 | 41,689,410           | 83,357,650  | 166,713,666 | 333,406,162   | 666,810,690   |



## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Physical Capacity Management

### Performance

For SSDs designed for the client and cloud computing markets, Micron specifies performance in fresh-out-of-box (FOB) state and steady state. Data throughput measured in steady state may be lower than FOB state, depending on the nature of the data workload.

For a description of these performance states and of Micron's best practices for performance measurement, refer to Micron's technical marketing brief Best Practices for SSD Performance Measurement.

**Table 11: Drive Performance With/Without HMB Enabled (SLC Mode=100%) – Fresh Out of Box**

| Capacity                          | 64GB    |        | 128GB   |        | 256GB   |        | 512GB   |        | 1024GB  |        | Unit |
|-----------------------------------|---------|--------|---------|--------|---------|--------|---------|--------|---------|--------|------|
| Actual Capacity                   | 21GB    |        | 42GB    |        | 85GB    |        | 170GB   |        | 341GB   |        |      |
| Parameter                         | HMB Off | HMB On | HMB Off | HMB On | HMB Off | HMB On | HMB Off | HMB On | HMB Off | HMB On |      |
| Sequential read (128KB transfer)  | 550     | 550    | 1100    | 1100   | 2000    | 2000   | 2000    | 2000   | 2000    | 2000   | MB/s |
| Sequential write (128KB transfer) | 250     | 250    | 500     | 500    | 1000    | 1000   | 1700    | 1700   | 1800    | 1800   | MB/s |
| Random read (4KB transfer)        | 12K     | 25K    | 20K     | 50K    | 38K     | 100K   | 65K     | 170K   | 105K    | 200K   | IOPS |
| Random write (4KB transfer)       | 48K     | 48K    | 90K     | 100K   | 160K    | 185K   | 170K    | 190K   | 189K    | 210K   | IOPS |
| READ latency (TYP)                | 85      | 85     | 85      | 85     | 85      | 85     | 85      | 85     | 85      | 85     | μs   |
| WRITE latency (TYP)               | 40      | 40     | 40      | 40     | 40      | 40     | 40      | 40     | 40      | 40     | μs   |

- Notes:
1. Performance values measured in fresh-out-of-box (FOB) state using FIO with a queue depth of 32.
  2. Drive write cache enabled.
  3. NVMe power state 0.
  4. 4KB transfers with a queue depth of 1 are used to measure READ/WRITE latency values.
  5. 4KB transfers can be further improved with the support of HMB by the host.
  6. System variations will affect measured results.



## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Component Electrical Characteristics

### Component Electrical Characteristics

Environmental conditions beyond those listed may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

### BGA Type

**Table 12: Power Consumption**

| Capacity | NVMe Power<br>State 4<br>Sleep | NVMe Power<br>State 3<br>Slumber | NVMe Power State 0   |              |               | Unit |
|----------|--------------------------------|----------------------------------|----------------------|--------------|---------------|------|
|          |                                |                                  | Idle Power<br>(IDLP) | Active Reads | Active Writes |      |
| 64GB     | 3                              | <80                              | <100                 | <3000        | <3000         | mW   |
| 128GB    | 3                              | <80                              | <100                 | <3000        | <3000         | mW   |
| 256GB    | 3                              | <80                              | <100                 | <3000        | <3000         | mW   |
| 512GB    | 3                              | <80                              | <150                 | <3000        | <4000         | mW   |
| 1024GB   | 3                              | <80                              | <200                 | <3000        | <5000         | mW   |

- Notes:
1. Active reads/actives write power is an average power measurement performed using FIO with 128KB sequential read/write transfers respectively.
  2. For power states 3 and power state 4 average power measurements, the PCIe state is set to L1.2 link state.

**Table 13: Maximum Current per Power Rail**

| Parameter<br>Symbol/<br>Capacity | 64GB           |                 | 128GB          |                 | 256GB          |                 | 512GB          |                 | 1024GB         |                 | Unit |
|----------------------------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|----------------|-----------------|------|
|                                  | Active<br>Read | Active<br>Write | Active<br>Read | Active<br>Write | Active<br>Read | Active<br>Write | Active<br>Read | Active<br>Write | Active<br>Read | Active<br>Write |      |
| PWR_1                            | 75             | 75              | 115            | 115             | 170            | 165             | 175            | 290             | 195            | 290             | mA   |
| PWR_2                            | 130            | 110             | 160            | 125             | 240            | 150             | 405            | 295             | 420            | 330             | mA   |
| PWR_3                            | 1555           | 1295            | 1475           | 1220            | 1575           | 1320            | 1535           | 1280            | 1600           | 1345            | mA   |

- Notes:
1. The data is obtained from limited samples.
  2. Average maximum current over any 8ms time interval.

**Table 14: Operating Ratings**

| Parameter Symbol/Condition                             | Nominal        | Min  | Max   | Unit |
|--------------------------------------------------------|----------------|------|-------|------|
| PWR_1                                                  | 3.3            | 2.97 | 3.63  | V    |
| PWR_2                                                  | 1.2            | 1.14 | 1.26  | V    |
| PWR_3                                                  | 0.9            | 0.86 | 0.945 | V    |
| Delay in between the power-off and power-on (all PWRs) |                | 1    |       | s    |
| Operating temperature <sup>1,4</sup>                   | T <sub>C</sub> | -40  | 95    | °C   |
| Sensor temperature <sup>2, 3</sup>                     | T <sub>S</sub> | -55  | 135   | °C   |



## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Component Electrical Characteristics

**Table 14: Operating Ratings (Continued)**

| Parameter Symbol/Condition                            | Nominal | Min | Max | Unit    |
|-------------------------------------------------------|---------|-----|-----|---------|
| Non-operating ambient temperature                     | -       | -40 | 105 | °C      |
| Rate of temperature change(both operating & unbiased) | -       | -   | 90  | °C/hour |
| Relative humidity (non-condensing)                    | -       | 5   | 95  | %       |

- Notes:
1. Operating temperature is the case surface temperature at the center of the top side of the device.
  2. Temperature is measured by SMART. Sensor temperature represents the  $T_J$  of the SSD micro-controller. The reported temperature is expected to be slightly greater than Operating temperature  $T_C$ . The temperature difference will be highest at heavy workload and without air-flow.
  3. If SMART temperature (Log Identifier 02h) exceeds 115°C, performance will be throttled. Sensor temperature range has been characterised on limited samples.
  4. Refer to *TN-00-08* for method and the criteria to ensure that the memory operates below its maximum allowable temperature.
  5. Refer to *TN-FD-50: 2100AT Power Supply Electrical Requirements* for further information about power on/off and power cycle requirements.





## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Modules Electrical Characteristics

### Modules Electrical Characteristics

Environmental conditions beyond those listed may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

### M.2 Type

**Table 15: Power Consumption**

| Capacity | NVMe Power<br>State 4<br>Sleep | NVMe Power<br>State 3<br>Slumber | NVMe Power State 0   |              |               | Unit |
|----------|--------------------------------|----------------------------------|----------------------|--------------|---------------|------|
|          |                                |                                  | Idle Power<br>(IDLP) | Active Reads | Active Writes |      |
| 128GB    | 5                              | <80                              | <100                 | <3000        | <3000         | mW   |
| 256GB    | 5                              | <80                              | <100                 | <3000        | <3000         | mW   |
| 512GB    | 5                              | <80                              | <150                 | <3000        | <4000         | mW   |
| 1024GB   | 5                              | <80                              | <200                 | <3000        | <5000         | mW   |

- Notes:
1. Active reads/active writes power is an average power measurement performed using FIO with 128KB sequential read/write transfers.
  2. For Power States 3 and 4 average power measurements, the PCIe is set to L1.2 link state.

**Table 16: Operating Ratings**

| Signal Name/Condition                                  | Nominal        | Min   | Max   | Unit    |
|--------------------------------------------------------|----------------|-------|-------|---------|
| 3.3V                                                   | 3.3V           | 3.135 | 3.465 | V       |
| Delay in between the power-off and power-on (3.3V)     |                | 1     |       | s       |
| Operating temperature <sup>1</sup>                     | T <sub>C</sub> | -40   | 95    | °C      |
| Sensor temperature <sup>2, 3</sup>                     | T <sub>S</sub> | -55   | 135   | °C      |
| Non-operating ambient temperature                      | -              | -40   | 105   | °C      |
| Rate of temperature change (both operating & unbiased) | -              | -     | 90    | °C/hour |
| Relative humidity (non-condensing)                     | -              | 5     | 95    | %       |

- Notes:
1. Operating temperature is the case surface temperature at the center of the top side of the device.
  2. If SMART temperature (log identifier 02h) exceeds 115°C, performance will be throttled.
  3. Temperature is measured by SMART. Sensor temperature range has been characterised on limited samples.

**Table 17: Shock and Vibration**

| Parameter/Condition     | Specification             |
|-------------------------|---------------------------|
| Non-operating shock     | 1500G @ 0.5ms half sine   |
| Non-operating vibration | Random vibration 7-2000Hz |



## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Identify – Identify Controller Data Structure

### Identify – Identify Controller Data Structure

**Table 18: Identify – Identify Controller Data Structure**

| Bytes  | Default Value | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 01:00  | 1344h         | <b>PCI Vendor ID (VID):</b> Contains the Micron identifier assigned by the PCI SIG.                                                                                                                                                                                                                                                                                                                                                                        |
| 03:02  | 1344h         | <b>PCI Subsystem Vendor ID (SSVID):</b> Contains the Micron identifier assigned by the PCI SIG for the subsystem.                                                                                                                                                                                                                                                                                                                                          |
| 23:04  | Variable      | <b>Serial Number (SN):</b> Contains the serial number for the NVM subsystem as an ASCII string.                                                                                                                                                                                                                                                                                                                                                            |
| 63:24  | Variable      | <b>Model Number (MN):</b> Contains the model number for the NVM subsystem as an ASCII string.                                                                                                                                                                                                                                                                                                                                                              |
| 71:64  | Variable      | <b>Firmware Revision (FR):</b> Contains the currently active firmware revision for the NVM subsystem.                                                                                                                                                                                                                                                                                                                                                      |
| 72     | 06            | <b>Recommended Arbitration Burst (RAB):</b> This is the recommended arbitration burst size.                                                                                                                                                                                                                                                                                                                                                                |
| 75:73  | 00h-A0h-75h   | <b>IEEE OUI Identifier (IEEE):</b> Contains the organization unique identifier (24bit OUI MA-L Format).                                                                                                                                                                                                                                                                                                                                                    |
| 76     | 0             | <b>Controller Multi-Path I/O and Namespace Sharing Capabilities (CMIC):</b> This field specifies multi-path I/O and namespace sharing capabilities of the controller and NVM subsystem.<br>Bits 7:3 are reserved<br>Bit 2 = 0 the controller is associated with a PCI function<br>Bit 1 = 0 the NVM subsystem contains only a single controller<br>Bit 0 = 0 the NVM subsystem contains only a single PCI Express port                                     |
| 77     | 6             | <b>Maximum Data Transfer Size (MDTS):</b> This field indicates the maximum data transfer size between the host and the controller. The host should not submit a command that exceeds this transfer size. If a command is submitted that exceeds the transfer size, then the command is aborted with a status of Invalid Field in command. The value is in units of the minimum memory page size (4096 bytes) and is reported as a power of two ( $2^n$ ).  |
| 79:78  | 0001          | <b>Controller ID (CNTLID):</b> Contains the NVM subsystem unique controller identifier associated with the controller.                                                                                                                                                                                                                                                                                                                                     |
| 83:80  | 10300h        | <b>Version (VER):</b> This register indicates the major and minor version of the NVM Express specification that the controller implementation supports.                                                                                                                                                                                                                                                                                                    |
| 87:84  | 000249F0h     | <b>RTD3 Resume Latency (RTD3R):</b> This field indicates the typical latency in microseconds resuming from Runtime D3 (RTD3).                                                                                                                                                                                                                                                                                                                              |
| 91:88  | 00013880h     | <b>RTD3 Entry Latency (RTD3E):</b> This field indicates the typical latency in microseconds to enter Runtime D3 (RTD3).                                                                                                                                                                                                                                                                                                                                    |
| 95:92  | 00000200h     | <b>Optional Asynchronous Events Supported (OAES):</b> This field indicates the optional asynchronous events supported by the controller. A controller shall not send optional asynchronous events before they are enabled by host software.<br>Bits 31:10 are reserved<br>Bit 9 = 1 the controller support sending Firmware Activation Notices<br>Bit 8 = 0 the controller does not support the Namespace Attribute Changed event<br>Bits 7:0 are reserved |
| 239:96 | –             | Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                   |



## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Identify – Identify Controller Data Structure

**Table 18: Identify – Identify Controller Data Structure (Continued)**

| Bytes   | Default Value     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 239:100 | –                 | Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 255:240 | –                 | Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 257:256 | 0000000000011111b | <b>Optional Admin Command Support (OACS):</b> This field indicates the optional Admin commands supported by the controller.<br>Bits 15:5 are reserved.<br>Bit 4 = 1 the controller supports the DEVICE SELF TEST (DST) command<br>Bit 3 = 1 the controller support the NAMESPACE MANAGEMENT and NAMESPACE ATTACHMENT commands<br>Bit 2 = 1 the controller supports the FIRMWARE COMMIT and FIRMWARE IMAGE DOWNLOAD commands<br>Bit 1 = 1 the controller supports the FORMAT NVM command<br>Bit 0 = 1 the controller supports the SECURITY SEND and SECURITY RECEIVE commands |
| 258     | 04h               | <b>Abort Command Limit (ACL):</b> This field is used to convey the maximum number of concurrently outstanding ABORT commands supported by the controller. This is a 0's based value.                                                                                                                                                                                                                                                                                                                                                                                         |
| 259     | 07h               | <b>Asynchronous Event Request Limit (AERL):</b> This field is used to convey the maximum number of concurrently outstanding ASYNCHRONOUS EVENT REQUEST commands supported by the controller. This is a 0's based value.                                                                                                                                                                                                                                                                                                                                                      |
| 260     | 000010110b        | <b>Firmware Updates (FRMW):</b> This field indicates capabilities regarding firmware updates.<br>Bits 7:5 are reserved.<br>Bit 4 = 1 the controller does not support firmware activation without a reset<br>Bits 3:1 = up to 3 the number of firmware slots that the controller supports (depending on OEM)<br>Bit 0 = 0 the first firmware slot (slot 1) is read/write                                                                                                                                                                                                      |
| 261     | 00000111b         | <b>Log Page Attributes (LPA):</b> This field indicates optional attributes for log pages that are accessed via the GET LOG PAGE command.<br>Bits 7:4 are reserved.<br>Bit 3 = 0 "Telemetry Host/Controller-Initiated Log Pages" not supported<br>Bit 2 = 1 the controller supports get log page<br>Bit 1 = 1 the controller supports the Command Effects log page<br>Bit 0 = 1 the controller supports the SMART/Health Information log page on a per namespace basis                                                                                                        |
| 262     | 3Fh               | <b>Error Log Page Entries (ELPE):</b> This field indicates the number of Error Information log entries that are stored by the controller. This field is a 0's based value.                                                                                                                                                                                                                                                                                                                                                                                                   |
| 263     | 4h                | <b>Number of Power States Support (NPSS):</b> This field indicates the number of NVM Express power states supported by the controller. This is a 0's based value.                                                                                                                                                                                                                                                                                                                                                                                                            |
| 264     | 1                 | Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 265     | 00000001b         | <b>Autonomous Power State Transition Attributes (APSTA):</b> This field indicates the attributes of the autonomous power state transition feature.<br>Bits 7:1 are reserved.<br>Bit 0 = 1 the controller supports autonomous power state transitions                                                                                                                                                                                                                                                                                                                         |



## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Identify – Identify Controller Data Structure

**Table 18: Identify – Identify Controller Data Structure (Continued)**

| Bytes   | Default Value     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 267:266 | 184h              | <b>Warning Composite Temperature Threshold (WCTEMP):</b> This field indicates the minimum Composite Temperature field value (Temperature value reported in the SMART/Health Information log) that indicates an overheating condition during which controller operation continues. Immediate remediation is recommended (for example, additional cooling or workload reduction). The platform should strive to maintain a composite temperature below this value. |
| 269:268 | 18Ch              | <b>Critical Composite Temperature Threshold (CCTEMP):</b> This field indicates the minimum Composite Temperature field value (Temperature value reported in the SMART/Health Information log) that indicates a critical overheating condition (for example, automatic device shutdown).                                                                                                                                                                          |
| 271:270 | 32h               | <b>Maximum Time for Firmware Activation (MTFA):</b> Indicates the maximum time the controller temporarily stops processing commands to activate the firmware image. This field is specified in 100 millisecond units.                                                                                                                                                                                                                                            |
| 275:272 | 4000h             | <b>Host Memory Buffer Preferred Size (HMPRE):</b> Host Memory Buffer Preferred Size.                                                                                                                                                                                                                                                                                                                                                                             |
| 279:276 | 2000h             | <b>Host Memory Buffer Minimum Size (HMMIN):</b> Host Memory Buffer Minimum Size.                                                                                                                                                                                                                                                                                                                                                                                 |
| 295:280 | Density Specific  | <b>Total NVM Capacity (TNVMCAP):</b> Total NVM capacity depends on density: 0xEE8156000 (64GB), 0x1DCF856000 (128GB), 0x3B9E656000 (256GB), 0x773C256000 (512GB), 0xEE77A56000 (1024GB)                                                                                                                                                                                                                                                                          |
| 311:296 | Density Specific  | <b>Unallocated NVM Capacity (UNVMCAP):</b> Unallocated NVM Capacity is supported. Value change runtime depending on SSD usage,                                                                                                                                                                                                                                                                                                                                   |
| 315:312 | 00000001h         | <b>Replay Protected Memory Block Support (RPMBS):</b> One single Replay Protected Memory Blocks is supported.                                                                                                                                                                                                                                                                                                                                                    |
| 317:316 | 000Ah             | <b>Extended Device Self-test Time (EDSTT):</b> This field indicates the nominal amount of time in one minute units that the controller takes to complete an extended DEVICE SELF TEST operation when in power state 0.                                                                                                                                                                                                                                           |
| 318     | 1                 | <b>Device Self-test Options (DSTO):</b> This field indicates the controller supports one DEVICE SELF TEST operation in progress at a time.                                                                                                                                                                                                                                                                                                                       |
| 319     | 00h               | <b>Firmware Update Granularity (FWUG) :</b> This field indicates the controller supports the Firmware Upgrade Granularity.                                                                                                                                                                                                                                                                                                                                       |
| 321:320 | 0                 | <b>Keep Alive Support (KAS):</b> Keep Alive is not supported.                                                                                                                                                                                                                                                                                                                                                                                                    |
| 323:322 | 111h (273K=0°C)   | <b>Host Controlled Thermal Management Attributes (HCTMA):</b> This field indicates the attributes of the host controlled thermal management feature. Bits 15:1 are reserved.<br>Bit 0 = 0 the controller does not support host controlled thermal management                                                                                                                                                                                                     |
| 325:324 | 184h (388K=115°C) | <b>Minimum Thermal Management Temperature (MNTMT):</b> This field indicates the minimum temperature, in degrees Kelvin, that the host may request in the Thermal Management Temperature 1 field and Thermal Management Temperature 2 field of a SET FEATURES command.                                                                                                                                                                                            |
| 327:326 | 0000h             | <b>Maximum Thermal Management Temperature (MXTMT):</b> This field indicates the maximum temperature, in degrees Kelvin, that the host may request in the Thermal Management Temperature 1 field and Thermal Management Temperature 2 field of a SET FEATURES command.                                                                                                                                                                                            |





## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Identify – Identify Controller Data Structure

**Table 18: Identify – Identify Controller Data Structure (Continued)**

| Bytes   | Default Value     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 331:328 | 0003h             | <b>Sanitize Capabilities (SANICAP):</b> This field indicates attributes for sanitize operations. If the Sanitize command is supported then this field shall be non-zero                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 511:332 | –                 | Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 512     | 66h               | <b>Submission Queue Entry Size (SQES):</b> This field defines the required and maximum submission queue entry size when using the NVM command set.<br>Bits 7:4 = 6 defines the maximum submission queue entry size when using the NVM command set. The value is in bytes and is reported as a power of two ( $2^n$ )<br>Bits 3:0 = 6 defines the required submission queue entry size when using the NVM command set. The value is in bytes and is reported as a power of two ( $2^n$ )                                                                                                                                                                                   |
| 513     | 44h               | <b>Completion Queue Entry Size (CQES):</b> This field defines the required and maximum completion queue entry size when using the NVM command set.<br>Bits 7:4 = 4 defines the maximum completion queue entry size when using the NVM command set. The value is in bytes and is reported as a power of two ( $2^n$ )<br>Bits 3:0 = 4 defines the required completion queue entry size when using the NVM command set. The value is in bytes and is reported as a power of two ( $2^n$ )                                                                                                                                                                                   |
| 515:514 | 0                 | <b>Maximum Outstanding Commands (MAXCMD):</b> Maximum Outstanding Commands is not supported.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 519:516 | 4                 | <b>Number of Namespaces (NN):</b> This field defines the number of valid namespaces present for the controller.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 521:520 | 0000000001010101b | <b>Optional NVM Command Support (ONCS):</b> This field indicates the optional NVM commands and features supported by the controller.<br>Bits 15:7 are reserved.<br>Bit 6 = 1 timestamp supported<br>Bit 5 = 0 the controller does not support reservations<br>Bit 4 = 1 the controller supports the save field in the SET FEATURES command and the select field in the GET FEATURES command<br>Bit 3 = 0 the controller does not support the WRITE ZEROS command<br>Bit 2 = 1 the controller supports the DATASET MANAGEMENT command<br>Bit 1 = 0 the controller does not support the WRITE UNCORRECTABLE command<br>Bit 0 = 1 the controller support the COMPARE command |
| 523:522 | 0                 | <b>Fused Operation Support (FUSES):</b> Fused Operation is not supported.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 524     | 00000111b         | <b>Format NVM Attributes (FNA):</b> This field indicates attributes for the FORMAT NVM command.<br>Bits 7:3 are reserved.<br>Bit 2 = 1 indicates cryptographic erase is supported as part of the secure erase functionality<br>Bit 1 = 1 user data erase of a particular namespace as part of a format results in a user data erase of all namespaces<br>Bit 0 = 1 all namespaces shall be configured with the same attributes and a format of any namespace results in a format of all namespaces                                                                                                                                                                        |



## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Identify – Identify Controller Data Structure

**Table 18: Identify – Identify Controller Data Structure (Continued)**

| Bytes     | Default Value                    | Description                                                                                                                                                                                                                                                                                                                                                                             |
|-----------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 525       | 00000001b                        | <b>Volatile Write Cache (VWC):</b> This field indicates attributes related to the presence of a volatile write cache in the implementation.<br>Bits 7:1 are reserved.<br>Bit 0 = 1 volatile write cache is present. The host may issue FLUSH commands and control whether the volatile write cache is enabled with SET FEATURES specifying the volatile write cache feature identifier. |
| 527:526   | 0                                | <b>Atomic Write Unit Normal (AWUN)</b> is not supported.                                                                                                                                                                                                                                                                                                                                |
| 529:528   | 0                                | <b>Atomic Write Unit Power Fail (AWUPF)</b> is not supported.                                                                                                                                                                                                                                                                                                                           |
| 530       | 1                                | <b>NVM Vendor Specific Command Configuration (NVSCC)</b>                                                                                                                                                                                                                                                                                                                                |
| 531       | –                                | Reserved.                                                                                                                                                                                                                                                                                                                                                                               |
| 533:532   | 0                                | <b>Atomic Compare &amp; Write Unit (ACWU):</b> Atomic Compare & Write Unit is not supported.                                                                                                                                                                                                                                                                                            |
| 535:534   | –                                | Reserved                                                                                                                                                                                                                                                                                                                                                                                |
| 539:536   | 0                                | <b>SGL Support (SGLS):</b> SGL is not supported.                                                                                                                                                                                                                                                                                                                                        |
| 767:540   | –                                | Reserved.                                                                                                                                                                                                                                                                                                                                                                               |
| 1023:768  | Variable                         | <b>NVM Subsystem NVMe Qualified Name (SUBNQN):</b> This field specifies the NVM Subsystem NVMe Qualified Name as a UTF-8 null-terminated string.                                                                                                                                                                                                                                        |
| 2047:1024 | –                                | Reserved                                                                                                                                                                                                                                                                                                                                                                                |
| 2079:2048 | Density Specific                 | <b>Power State 0 Descriptor (PSD0):</b> This field indicates the characteristics of power state 0. The format of this field is defined in Table 19.                                                                                                                                                                                                                                     |
| 2111:2080 | Density Specific                 | <b>Power State 1 Descriptor (PSD1):</b> This field indicates the characteristics of power state 1. The format of this field is defined in Table 19.                                                                                                                                                                                                                                     |
| 2143:2112 | Density Specific                 | <b>Power State 2 Descriptor (PSD2):</b> This field indicates the characteristics of power state 2. The format of this field is defined in Table 19.                                                                                                                                                                                                                                     |
| 2175:2144 | 303030300003A9800001F40030008DEh | <b>Power State 3 Descriptor (PSD3):</b> This field indicates the characteristics of power state 3. The format of this field is defined in Table 19.                                                                                                                                                                                                                                     |
| 2207:2176 | 40404040000C3500000271003000082h | <b>Power State 4 Descriptor (PSD4):</b> This field indicates the characteristics of power state 4. The format of this field is defined in Table 19.                                                                                                                                                                                                                                     |
| 327F:2208 | -                                | Reserved.                                                                                                                                                                                                                                                                                                                                                                               |
| 3280      | Variable                         | <b>Physical Capacity Management Attribute (PCMA):</b> This field indicates the attributes and support of the Physical Capacity Management feature.                                                                                                                                                                                                                                      |
| 3281      | Variable                         | <b>Maximum Namespaces in SLC Physical Configuration (MNSPC):</b> This field indicates the maximum amount of namespaces the SLC physical space can support in the current physical configuration.                                                                                                                                                                                        |
| 3282      | Variable                         | <b>Maximum Namespace in TLC Physical Configuration (MNTPC):</b> This field indicates the maximum amount of namespaces the TLC physical space can support in the current physical configuration.                                                                                                                                                                                         |
| 3298:3283 | Variable                         | <b>Total SLC NVM Capacity (TSNCAP):</b> This field indicates the total SLC NVM capacity in the NVM subsystem for the current physical configuration. The value is in bytes.                                                                                                                                                                                                             |





## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Identify – Identify Controller Data Structure

**Table 18: Identify – Identify Controller Data Structure (Continued)**

| Bytes       | Default Value | Description                                                                                                                                                                 |
|-------------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3314 : 3299 | Variable      | <b>Total TLC NVM Capacity (TTNCAP):</b> This field indicates the total TLC NVM capacity in the NVM subsystem for the current physical configuration. The value is in bytes. |
| 4095:3315   | –             | Reserved.                                                                                                                                                                   |

**Table 19: Power State Descriptor Data Structure**

| Bits    | Description                                                                                                                                                                                                                                                                                                                                        |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 15:0    | <b>Maximum Power (MP):</b> This field indicates the maximum power consumed by the NVM subsystem in this power state. The power in Watts is equal to the value in this field multiplied by the scale specified in the Maximum Power Scale field.                                                                                                    |
| 23:16   | Reserved                                                                                                                                                                                                                                                                                                                                           |
| 24      | <b>Max Power Scale (MPS):</b> This field indicates the scale for the Maximum Power field. If this field is cleared to 0, then the scale of the Maximum Power field is in 0.01 Watts. If this field is set to 1, then the scale of the Maximum Power field is in 0.0001 Watts.                                                                      |
| 25      | <b>Non-Operational State (NOPS):</b> This field indicates whether the controller processes I/O commands in this power state. If this field is cleared to 0, then the controller processes I/O commands in this power state. If this field is set to 1, then the controller does not process I/O commands in this power state.                      |
| 31:26   | Reserved                                                                                                                                                                                                                                                                                                                                           |
| 63:32   | <b>Entry Latency (ENLAT):</b> This field indicates the maximum entry latency in microseconds associated with entering this power state.                                                                                                                                                                                                            |
| 95:64   | <b>Exit Latency (EXLAT):</b> This field indicates the maximum exit latency in microseconds associated with exiting this power state.                                                                                                                                                                                                               |
| 100:96  | <b>Relative Read Throughput (RRT):</b> This field indicates the relative read throughput associated with this power state. A lower value means higher read throughput.                                                                                                                                                                             |
| 103:101 | Reserved                                                                                                                                                                                                                                                                                                                                           |
| 108:104 | <b>Relative Read Latency (RRL):</b> This field indicates the relative READ latency associated with this power state. A lower value means lower READ latency.                                                                                                                                                                                       |
| 111:109 | Reserved                                                                                                                                                                                                                                                                                                                                           |
| 116:112 | <b>Relative Write Throughput (RWT):</b> This field indicates the relative write throughput associated with this power state. A lower value means higher write throughput.                                                                                                                                                                          |
| 119:117 | Reserved                                                                                                                                                                                                                                                                                                                                           |
| 124:120 | <b>Relative Write Latency (RWL):</b> This field indicates the relative WRITE latency associated with this power state. A lower value means lower WRITE latency.                                                                                                                                                                                    |
| 127:125 | Reserved                                                                                                                                                                                                                                                                                                                                           |
| 143:128 | <b>Idle Power (IDLP):</b> This field indicates the typical power consumed by the NVM subsystem over 30 seconds in this power state when idle. The measurement starts after the NVM subsystem has been idle for 10 seconds. The power in Watts is equal to the value in this field multiplied by the scale indicated in the Idle Power Scale field. |
| 149:144 | Reserved                                                                                                                                                                                                                                                                                                                                           |
| 151:150 | <b>Idle Power Scale (IPS):</b> This field indicates the scale for the Idle Power field.                                                                                                                                                                                                                                                            |



## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Identify – Identify Controller Data Structure

**Table 19: Power State Descriptor Data Structure (Continued)**

| Bits    | Description                                                                                                                                                                                                                                                                                                                                    |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 159:152 | Reserved                                                                                                                                                                                                                                                                                                                                       |
| 175:160 | <b>Active Power (ACTP):</b> This field indicates the largest average power consumed by the NVM subsystem over a 10 second period in this power state with the workload indicated in the Active Power Workload field. The power in Watts is equal to the value in this field multiplied by the scale indicated in the Active Power Scale field. |
| 178:176 | <b>Active Power Workload (APW):</b> This field indicates the workload used to calculate maximum power for this power state.                                                                                                                                                                                                                    |
| 181:179 | Reserved                                                                                                                                                                                                                                                                                                                                       |
| 183:182 | <b>Active Power Scale (APS):</b> This field indicates the scale for the Active Power field.                                                                                                                                                                                                                                                    |
| 255:184 | Reserved                                                                                                                                                                                                                                                                                                                                       |



## Identify – Identify Namespace Data Structure

**Table 20: Identify – Identify Namespace Data Structure**

| Byte  | Default Value | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 07:00 | Variable      | <b>Namespace Size (NSZE):</b> This field indicates the total size of the namespace in logical blocks. A namespace of size n consists of LBA 0 through (n - 1). The number of logical blocks is based on the formatted LBA size.                                                                                                                                                                                                                                                                                         |
| 15:08 | Variable      | <b>Namespace Capacity (NCAP):</b> This field indicates the maximum number of logical blocks that may be allocated in the namespace at any point in time. The number of logical blocks is based on the formatted LBA size. A logical block is allocated when it is written with a WRITE or WRITE UNCORRECTABLE command. A logical block may be deallocated using the DATA-SET MANAGEMENT command.                                                                                                                        |
| 23:16 | Variable      | <b>Namespace Utilization (NUSE):</b> This field indicates the current number of logical blocks allocated in the namespace. This field is equal to the Namespace Capacity. The number of logical blocks is based on the formatted LBA size. When using the NVM command set: A logical block is allocated when it is written with a WRITE or WRITE UNCORRECTABLE command. A logical block may be deallocated using the DATASET MANAGEMENT command.                                                                        |
| 24    | 00000100b     | <b>Namespace Features (NSFEAT):</b> This field defines features of the namespace.<br>Bits 7:4 are reserved<br>Bit 3 = 0 the NGUID and EUI64 fields for this namespace are reused by the controller<br>Bit 2 = 1 the controller does support the Deallocated or Unwritten Logical Block error<br>Bit 1 = 0 the controller does not support the fields NAWUN, NAWUPF, and NACWU for the namespace<br>Bit 0 = 0 thin provisioning is not supported, the Namespace Size and Namespace Capacity fields report the same value |
| 25    | 0             | <b>Number of LBA Formats (NLBAF):</b><br><br>This field defines the number of supported LBA data sizes supported by the namespace. This is a 0's based value.                                                                                                                                                                                                                                                                                                                                                           |
| 26    | 00000000b     | <b>Formatted LBA Size (FLBAS):</b> This field indicates the LBA data size that the namespace has been formatted with.<br>Bits 7:5 are reserved<br>Bit 4 = 0 the controller does not support metadata<br>Bits 3:0 = 0. Indicates one of the 2 supported LBA formats indicated in this data structure.                                                                                                                                                                                                                    |
| 27    | 0             | <b>Metadata Capabilities (MC):</b> Metadata Capabilities is not supported.                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 28    | 0             | <b>End-to-end Data Protection Capabilities (DPC):</b> End-to-end Data Protection Capabilities is not supported.                                                                                                                                                                                                                                                                                                                                                                                                         |
| 29    | 0             | <b>End-to-end Data Protection Type Settings (DPS):</b> End-to-end Data Protection Type Settings is not supported.                                                                                                                                                                                                                                                                                                                                                                                                       |
| 30    | 0             | <b>Namespace Multi-path I/O and Namespace Sharing Capabilities (NMIC):</b> Namespace Multi-path I/O and Namespace Sharing Capabilities is not supported.                                                                                                                                                                                                                                                                                                                                                                |
| 31    | 0             | <b>Reservation Capabilities (RESCAP):</b> Reservation Capabilities field is not supported.                                                                                                                                                                                                                                                                                                                                                                                                                              |



## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Identify – Identify Namespace Data Structure

**Table 20: Identify – Identify Namespace Data Structure (Continued)**

| Byte      | Default Value | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 32        | 1VVVVVVb      | <b>Format Progress Indicator (FPI):</b> If a format operation is in progress, this field indicates the percentage of the namespace that remains to be formatted.<br>Bit 7 = 1 the namespace supports the Format Progress Indicator defined by bits 6:0 in this field<br>Bits 6:0 = Variable. Indicates the percentage of the namespace that remains to be formatted (For example, a value of 25 indicates that 75% of the namespace has been formatted and 25% remains to be formatted). A value of 0 indicates that the namespace is formatted with the format specified by the FLBAS field in this data structure. |
| 33        | –             | Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 35:34     | 0             | <b>Namespace Atomic Write Unit Normal (NAWUN):</b> Namespace Atomic Write Unit Normal is not supported.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 37:36     | 0             | <b>Namespace Atomic Write Unit Power Fail (NAWUPF):</b> Namespace Atomic Write Unit Power Fail is not supported.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 39:38     | 0             | <b>Namespace Atomic Compare &amp; Write Unit (NACWU):</b> Namespace Atomic Compare & Write Unit is not supported.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 41:40     | 0             | <b>Namespace Atomic Boundary Size Normal (NABSN):</b> Namespace Atomic Boundary Size Normal is not supported.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 43:42     | 0             | <b>Namespace Atomic Boundary Offset (NABO):</b> Namespace Atomic Boundary Offset is not supported.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 45:44     | 0             | <b>Namespace Atomic Boundary Size Power Fail (NABSPF):</b> Namespace Atomic Boundary Size Power Fail is not supported.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 47:46     | –             | Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 63:48     | 0             | <b>NVM Capacity (NVMCAP):</b> This field indicates the total size of the NVM allocated to this namespace. The value is in bytes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 103:64    | –             | Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 119:104   | Variable      | <b>Namespace Globally Unique Identifier (NGUID):</b> This field contains the 128-bit Namespace Globally Unique Identifier value.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 127:120   | Variable      | <b>IEEE Extended Unique Identifier (EUI64):</b> This field contains the 64-bit IEEE Extended Unique Identifier value.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 131:128   | 90000         | <b>LBA Format 0 Support (LBAF0)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 135:132   | –             | <b>LBA Format 1 Support (LBAF1):</b> not supported                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 139:136   | –             | <b>LBA Format 2 Support (LBAF2):</b> not supported                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| ... – ... | –             | ...                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 191:188   | –             | <b>LBA Format 15 Support (LBAF15):</b> not supported                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 383:192   | –             | Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 384       | –             | <b>Namespace Physical NAND Configuration (NPNC):</b><br>Bits 7:2 are reserved<br>Bit 1 = 1 for TLC operation<br>Bit 0 = 1 for SLC operation of the Namespace                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 4095:385  | –             | <b>Vendor Specific (VS)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |



# 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Interface Signals

## Interface Signals

### BGA Type

Figure 3: Ballmap - BGA Type (Top View)

|    | 1   | 2   | 3   | 4       | 5       | 6   | 7      | 8       | 9     | 10    | 11    | 12    | 13      | 14  | 15   | 16  | 17       | 18         |
|----|-----|-----|-----|---------|---------|-----|--------|---------|-------|-------|-------|-------|---------|-----|------|-----|----------|------------|
| A  | DNU | DNU |     | DNU     |         | DNU |        | DNU     |       |       | DNU   |       | DNU     |     | DNU  |     | DNU      | DNU        |
| B  | DNU | DNU |     | DNU     |         | DNU |        | DNU     |       |       | DNU   |       | DNU     |     | DNU  |     | DNU      | DNU        |
| C  | GND | GND | GND | GND     | GND     | DNU | DNU    | DNU     | DNU   | DNU   | DNU   | DNU   | RFU     | RFU | GND  | DNU | DNU      | DNU        |
| D  |     |     |     | REFCLKp | REFCLKn | GND | PERST# | CLKREQ# | PWR_1 | PWR_1 | GND   | DNU   | UART_RX | RFU | RFU  |     |          |            |
| E  | GND | GND | GND | GND     | GND     | GND | GND    | DNU     | PWR_1 | PWR_1 | GND   | DNU   | UART_TX | GND | GND  | DNU | DNU      | DNU        |
| F  |     |     |     | PERp0   | PERn0   | GND |        |         |       |       |       |       |         | DNU | RFU  |     |          |            |
| G  | GND | GND | GND | GND     | GND     |     | PWR_3  | PWR_3   | GND   | GND   | PWR_3 | PWR_3 |         | GND | GND  | DNU | DNU      | DNU        |
| H  |     |     |     | PETp0   | PETn0   |     | PWR_3  | PWR_3   | GND   | GND   | PWR_3 | PWR_3 |         | RFU | PLN# |     |          |            |
| J  | GND | GND | GND | GND     | GND     |     | PWR_3  | PWR_3   | GND   | GND   | PWR_3 | PWR_3 |         | GND | GND  | DNU | DNU      | DNU        |
| K  |     |     |     | PERp1   | PERn1   |     | GND    | GND     | GND   | GND   | GND   | GND   |         | RFU | PLA# |     |          |            |
| L  | GND | GND | GND | GND     | GND     |     | RFU    | RFU     | RFU   | RFU   | RFU   | RFU   |         | GND | GND  | DNU | DNU      | JTAG_TRST# |
| M  |     |     |     | PETp1   | PETn1   |     | RFU    | RFU     | GND   | GND   | RFU   | RFU   |         | RFU | RFU  |     |          |            |
| N  | GND | GND | GND | GND     | GND     |     | RFU    | RFU     | RFU   | RFU   | RFU   | RFU   |         | GND | GND  | DNU | JTAG_TCK | JTAG_TMS   |
| P  |     |     |     | PERp2   | PERn2   |     | GND    | GND     | GND   | GND   | GND   | GND   |         | RFU | RFU  |     |          |            |
| R  | GND | GND | GND | GND     | GND     |     | PWR_2  | PWR_2   | GND   | GND   | PWR_2 | PWR_2 |         | GND | GND  | DNU | JTAG_TDI | JTAG_TDO   |
| T  |     |     |     | PETp2   | PETn2   |     | PWR_2  | PWR_2   | GND   | GND   | PWR_2 | PWR_2 |         | RFU | RFU  |     |          |            |
| U  | GND | GND | GND | GND     | GND     |     | PWR_2  | PWR_2   | GND   | GND   | PWR_2 | PWR_2 |         | GND | GND  | DNU | DNU      | DNU        |
| V  |     |     |     | PERp3   | PERn3   |     |        |         |       |       |       |       |         | RFU | RFU  |     |          |            |
| W  | GND | GND | GND | GND     | GND     | GND | LED_1# | RFU     | PWR_1 | PWR_1 | GND   | RFU   | RFU     | GND | GND  | DNU | DNU      | DNU        |
| Y  |     |     |     | PETp3   | PETn3   | GND | DNU    | DNU     | PWR_1 | PWR_1 | GND   | DNU   | GND     | DNU | DNU  |     |          |            |
| AA | GND | GND | GND | GND     | GND     | DNU | DNU    | DNU     | DNU   | DNU   | DNU   | DNU   | DNU     | GND | GND  | DNU | DNU      | DNU        |
| AB | DNU | DNU |     | DNU     |         | DNU |        | DNU     |       |       | DNU   |       | DNU     |     | DNU  |     | DNU      | DNU        |
| AC | DNU | DNU |     | DNU     |         | DNU |        | DNU     |       |       | DNU   |       | DNU     |     | DNU  |     | DNU      | DNU        |

Note: 1. Preliminary ballmap. Available signals are subject to change.





## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Interface Signals

**Table 21: BGA Signal Descriptions**

| Name             | Type | Power Domain      | Description                                                                                     |
|------------------|------|-------------------|-------------------------------------------------------------------------------------------------|
| PETp0, PETn0     | O    |                   | PCIe TX+ Lane 0, PCIe TX- Lane 0                                                                |
| PERp0, PERn0     | I    |                   | PCIe RX+ Lane 0, PCIe RX- Lane 0                                                                |
| PETp1, PETn1     | O    |                   | PCIe TX+ Lane 1, PCIe TX- Lane 1. It can be left floating                                       |
| PERp1, PERn1     | I    |                   | PCIe RX+ Lane 1, PCIe RX- Lane 1. It can be left floating                                       |
| PETp2, PETn2     | O    |                   | PCIe TX+ Lane 2, PCIe TX- Lane 2. It can be left floating                                       |
| PERp2, PERn2     | I    |                   | PCIe RX+ Lane 2, PCIe RX- Lane 2. It can be left floating                                       |
| PETp3, PETn3     | O    |                   | PCIe TX+ Lane 3, PCIe TX- Lane 3. It can be left floating                                       |
| PERp3, PERn3     | I    |                   | PCIe RX+ Lane 3, PCIe RX- Lane 3. It can be left floating                                       |
| REFCLKp, REFCLKn | I    |                   | 100 MHz reference clock+, 100 MHz reference clock-                                              |
| CLKREQ#          | OD   | (1.8V)            | Clock request                                                                                   |
| PERST#           | I    | (1.8V)            | PCIe Fundamental Reset                                                                          |
| LED_1#           | OD   | 3.3V              | Status indicator for system LED; Optional for customer. It can use 100 ohms to LED tied to 3.3V |
| UART_RX          | I    | 3.3V              | Engineering test. It can be left floating <sup>1</sup>                                          |
| UART_TX          | O    | 3.3V              | Engineering test. It can be left floating <sup>1</sup>                                          |
| JTAG_TRST#       | I    | 3.3V              | Engineering test. It can be left floating <sup>1</sup>                                          |
| JTAG_TDI         | I    | 3.3V              | Engineering test. It can be left floating <sup>1</sup>                                          |
| JTAG_TDO         | O    | 3.3V              | Engineering test. It can be left floating <sup>1</sup>                                          |
| JTAG_TCK         | I    | 3.3V              | Engineering test. It can be left floating <sup>1</sup>                                          |
| JTAG_TMS         | I    | 3.3V              | Engineering test. It can be left floating <sup>1</sup>                                          |
| PLN#             | I    | 3.3V <sup>6</sup> | Power Loss Notification. Pull-up when not driven.                                               |
| PLA#             | O    | 3.3V <sup>6</sup> | Power Loss Acknowledgement (default high).                                                      |
| PWR_1            | I    |                   | 3.3V power <sup>7</sup>                                                                         |
| PWR_2            | I    |                   | 1.2V power                                                                                      |
| PWR_3            | I    |                   | 0.9V power                                                                                      |
| RFU              | NA   | NA                | Reserved for future use <sup>2</sup>                                                            |
| DNU              | NA   | NA                | Do not use <sup>3</sup>                                                                         |

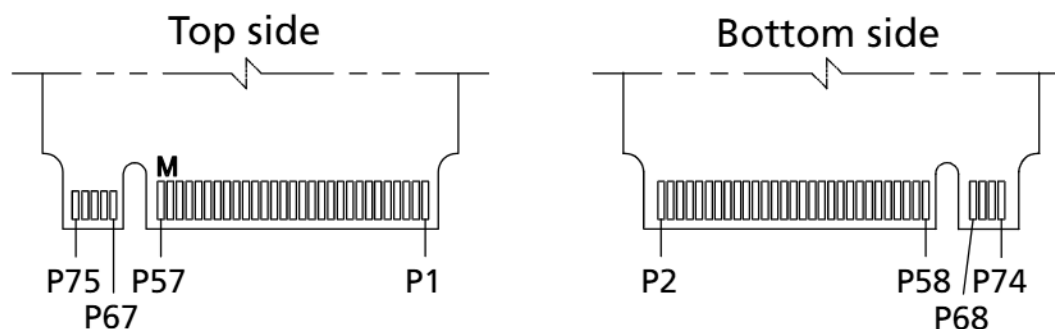
- Notes:
1. Engineering test signal should be routed to a test point pad. They are not intended for customer use since they have controlled access to insure security of data
  2. RFU signals are reserved for future use. These balls shall be soldered to a platform board, but shall be electrically no-connect on the host or the module
  3. DNU signals are for manufacturing only. These balls shall be soldered to a platform board, but shall be electrically no-connect on the host or the module
  4. Power domain (1.8V) is internally generated by an LDO
  5. Each PCIe in-band signal (PETxy/PERxy) requires AC coupling capacitance (75nF–500nF) close to the transmitter
  6. We recommend to make a design compatible with both 3.3V and 1.8V.
  7. We recommend to make a design compatible with 2.5V for next generation SSD.



## Interface Connectors

### M.2 Type

**Figure 4: Connector - M.2 Type**



**Table 22: Signal Assignments**

| Top Side |             |                 | Bottom Side |             |                         |
|----------|-------------|-----------------|-------------|-------------|-------------------------|
| Pin #    | Signal Name | Description     | Pin #       | Signal Name | Description             |
| 1        | GND         | Ground          | 2           | 3.3V        | +3.3V                   |
| 3        | GND         | Ground          | 4           | 3.3V        | +3.3V                   |
| 5        | PETn3       | PCIe TX- Lane 3 | 6           | NC6         | No connect              |
| 7        | PETp3       | PCIe TX+ Lane 3 | 8           | PLN#        | Power Loss Notification |
| 9        | GND         | Ground          | 10          | LED_1#      | LED Activity Indicator  |
| 11       | PERn3       | PCIe RX- Lane 3 | 12          | 3.3V        | +3.3V                   |
| 13       | PERp3       | PCIe RX+ Lane 3 | 14          | 3.3V        | +3.3V                   |
| 15       | GND         | Ground          | 16          | 3.3V        | +3.3V                   |
| 17       | PETn2       | PCIe TX- Lane 2 | 18          | 3.3V        | +3.3V                   |
| 19       | PETp2       | PCIe TX+ Lane 2 | 20          | NC20        | No connect              |
| 21       | GND         | Ground          | 22          | NC22        | No connect              |
| 23       | PERn2       | PCIe RX- Lane 2 | 24          | NC24        | No connect              |
| 25       | PERp2       | PCIe RX+ Lane 2 | 26          | NC26        | No connect              |
| 27       | GND         | Ground          | 28          | NC28        | No connect              |
| 29       | PETn1       | PCIe TX- Lane 1 | 30          | PLA#        | Power Loss Acknowledge  |
| 31       | PETp1       | PCIe TX+ Lane 1 | 32          | NC32        | No connect              |
| 33       | GND         | Ground          | 34          | NC34        | No connect              |
| 35       | PERn1       | PCIe RX- Lane 1 | 36          | NC36        | No connect              |
| 37       | PERp1       | PCIe RX+ Lane 1 | 38          | NC38        | No connect              |
| 39       | GND         | Ground          | 40          | NC40        | No connect              |
| 41       | PETn0       | PCIe TX- Lane 0 | 42          | NC42        | No connect              |
| 43       | PETp0       | PCIe TX+ Lane 0 | 44          | NC44        | No connect              |



## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Interface Connectors

**Table 22: Signal Assignments (Continued)**

| Top Side         |             |                 | Bottom Side      |             |                             |
|------------------|-------------|-----------------|------------------|-------------|-----------------------------|
| Pin #            | Signal Name | Description     | Pin #            | Signal Name | Description                 |
| 45               | GND         | Ground          | 46               | NC46        | No connect                  |
| 47               | PERn0       | PCIe RX– Lane 0 | 48               | NC48        | No connect                  |
| 49               | PERp0       | PCIe RX+ Lane 0 | 50               | PERST#      | PERST#                      |
| 51               | GND         | Ground          | 52               | CLKREQ#     | CLKREQ#                     |
| 53               | REFCLKn     | PCIe REFCLK–    | 54               | PEWAKE#     | No connect                  |
| 55               | REFCLKp     | PCIe REFCLK+    | 56               | UART_RX     | Reserved - Engineering test |
| 57               | GND         | Ground          | 58               | UART_TX     | Reserved - Engineering test |
| Mechanical M Key |             |                 | Mechanical M Key |             |                             |
| 67               | NC67        | No connect      | 68               | SUSCLK      | No connect                  |
| 69               | PEDET       | No connect      | 70               | 3.3V        | +3.3V                       |
| 71               | GND         | Ground          | 72               | 3.3V        | +3.3V                       |
| 73               | GND         | Ground          | 74               | 3.3V        | +3.3V                       |
| 75               | GND         | Ground          | –                | –           | –                           |



## Commands

**Table 23: Op Codes for Admin Commands**

Codes not listed are reserved. All commands in the table are supported.

| Command Name                                         | Op Code (hex)             |
|------------------------------------------------------|---------------------------|
| DELETE I/O SUBMISSION QUEUE                          | 00h                       |
| CREATE I/O SUBMISSION QUEUE                          | 01h                       |
| GET LOG PAGE                                         | 02h                       |
| DELETE I/O COMPLETION QUEUE                          | 04h                       |
| CREATE I/O COMPLETION QUEUE                          | 05h                       |
| IDENTIFY                                             | 06h                       |
| ABORT                                                | 08h                       |
| SET FEATURES – SET ARBITRATION                       | 09h - 01h                 |
| SET FEATURES – SET POWER MANAGEMENT                  | 09h - 02h                 |
| SET FEATURES – SET LBA RANGE TYPE                    | 09h - 03h                 |
| SET FEATURES – SET TEMPERATURE THRESHOLD             | 09h - 04h                 |
| SET FEATURES – SET ERROR RECOVERY                    | 09h - 05h                 |
| SET FEATURES – SET VOLATILE WRITE CACHE              | 09h - 06h                 |
| SET FEATURES – SET NUMBER OF QUEUES                  | 09h - 07h                 |
| SET FEATURES – SET INTERRUPT COALESCE                | 09h - 08h                 |
| SET FEATURES – SET INTERRUPT VECTOR CONFIGURATION    | 09h - 09h                 |
| SET FEATURES – SET WRITE ATOMICITY                   | 09h - 0Ah (Not Supported) |
| SET FEATURES – SET ASYNC EVENT CONFIGURATION         | 09h - 0Bh                 |
| SET FEATURES – SET AUTONOMOUS POWER STATE TRANSITION | 09h - 0Ch                 |
| SET FEATURES – SET HOST MEMORY BUFFER                | 09h - 0Dh                 |
| SET FEATURES - TIMESTAMP                             | 09h - 0Eh                 |
| SET FEATURES - KEEP ALIVE TIMER                      | 09h - 0Fh (Not Supported) |
| SET FEATURES – HOST CONTROLLED THERMAL MANAGEMENT    | 09h - 10h                 |
| SET FEATURES – NON OPERATIONAL POWER STATE CONFIG    | 09h - 11h                 |
| SET FEATURES – SW PROGRESS MARKER                    | 09h - 80h                 |
| SET FEATURES - RESERVATION PERSISTENCE               | 09h - 83h (Not Supported) |
| SET FEATURES - RESERVATION PERSISTENCE               | 09h - 83h (Not Supported) |
| SET FEATURES - RESERVATION PERSISTENCE               | 09h - 83h (Not Supported) |
| SET FEATURES – SET PLN/PLA FEATURES                  | 09h - CAh                 |
| SET FEATURES – SLC REFLOW MFG STATE                  | 09h - C6h                 |
| GET FEATURES – GET ARBITRATION                       | 0Ah - 01h                 |
| GET FEATURES – GET POWER MANAGEMENT                  | 0Ah - 02h                 |
| GET FEATURES – GET LBA RANGE TYPE                    | 0Ah - 03h                 |
| GET FEATURES – GET TEMPERATURE THRESHOLD             | 0Ah - 04h                 |
| GET FEATURES – GET ERROR RECOVERY                    | 0Ah - 05h                 |
| GET FEATURES – GET VOLATILE WRITE CACHE              | 0Ah - 06h                 |


**Table 23: Op Codes for Admin Commands (Continued)**

Codes not listed are reserved. All commands in the table are supported.

| Command Name                                         | Op Code (hex)             |
|------------------------------------------------------|---------------------------|
| GET FEATURES – GET NUMBER OF QUEUES                  | 0Ah - 07h                 |
| GET FEATURES – GET INTERRUPT COALESCE                | 0Ah - 08h                 |
| GET FEATURES – GET INTERRUPT VECTOR CONFIGURATION    | 0Ah - 09h                 |
| GET FEATURES – HOST CONTROLLED THERMAL MANAGEMENT    | 0Ah - 10h                 |
| GET FEATURES – GET WRITE ATOMICITY                   | 0Ah - 0Ah (Not Supported) |
| GET FEATURES – GET ASYNC EVENT CONFIGURATION         | 0Ah - 0Bh                 |
| GET FEATURES – GET AUTONOMOUS POWER STATE TRANSITION | 0Ah - 0Ch                 |
| GET FEATURES – GET HOST MEMORY BUFFER                | 0Ah - 0Dh                 |
| GET FEATURES - TIMESTAMP                             | 0Ah - 0Eh                 |
| GET FEATURES – HOST CONTROLLED THERMAL MANAGEMENT    | 0Ah - 10h                 |
| GET FEATURES – SW PROGRESS MARKER                    | 0Ah - 80h (Not Supported) |
| GET FEATURES – HOST IDENTIFIER                       | 0Ah - 81h (Not Supported) |
| GET FEATURES – RESERVATION NOTIFICATION MASK         | 0Ah - 82h (Not Supported) |
| GET FEATURES – RESERVATION PERSISTENCE               | 0Ah - 83h (Not Supported) |
| GET FEATURES – SLC REFLOW MFG STATE                  | 0Ah - C6h                 |
| GET FEATURES – ACCL. PROGRAM MFG STATE               | 0Ah - C9h (Not Supported) |
| ASYNCHRONOUS EVENT REQUEST                           | 0Ch (Not Supported)       |
| NAMESPACE MANAGEMENT                                 | 0Dh                       |
| FIRMWARE COMMIT / ACTIVATE                           | 10h                       |
| FIRMWARE IMAGE DOWNLOAD                              | 11h                       |
| DEVICE SELF TEST (DST)                               | 14h                       |
| DIRECTIVE SEND                                       | 19h (Not Supported)       |
| KEEP ALIVE                                           | 18h                       |
| DIRECTIVE RECEIVE                                    | 1Ah (Not Supported)       |
| PHYSICAL CAPACITY MANAGEMENT (Vendor Specific)       | C0h                       |
| LOCK PHYSICAL CONFIGURATION (Vendor Specific)        | C4h                       |
| FORMAT NVM                                           | 80h                       |
| SECURITY SEND                                        | 81h                       |
| SECURITY RECEIVE                                     | 82h                       |
| SANITIZE - BLOCK ERASE                               | 84h - 01h                 |
| SANITIZE - OVERWRITE                                 | 84h - 02h                 |
| SANITIZE - CRYPTO ERASE                              | 84h - 03h                 |





## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Commands

**Table 24: Op Codes for NVMe Commands**

Codes not listed are reserved. All commands in the table are supported.

| Command Name                                           | Op Code (hex)                    |
|--------------------------------------------------------|----------------------------------|
| FLUSH                                                  | 00h                              |
| WRITE                                                  | 01h                              |
| READ                                                   | 02h                              |
| WRITE UNCORRECTABLE                                    | 04h <sup>1</sup> (Not Supported) |
| COMPARE ZEROs                                          | 05h <sup>1</sup>                 |
| WRITE ZEROs                                            | 08h <sup>1</sup> (Not Supported) |
| DATASET MANAGEMENT – DEALLOCATE (AD)                   | 09h <sup>1</sup>                 |
| DATASET MANAGEMENT – INTEGRAL DATA SET FOR WRITE (IDW) | 09h <sup>1</sup>                 |
| DATASET MANAGEMENT – INTEGRAL DATA SET FOR READ (IDR)  | 09h <sup>1</sup>                 |
| RESERVATION REGISTER                                   | 0Dh (Not Supported)              |
| RESERVATION REPORT                                     | 0Eh (Not Supported)              |
| RESERVATION ACQUIRE                                    | 11h (Not Supported)              |
| RESERVATION RELEASE                                    | 15h (Not Supported)              |

Note: 1. 4KB LBA alignment is mandatory.



## Log Pages

The SSD supports log information as defined in the NVMe specification. Supported information is shown in the following tables:

- Error Information (Log Identifier 01h)
- SMART/Health Information (Log Identifier 02h)
- Firmware Slot Information (Log Identifier 03h)
- Commands Supported and Effects (Log Identifier 05h)
- Device Self-Test Log (Log Identifier 06h)

**Table 25: Error Information Log Entry (Log Identifier 01h)**

| Bytes | Name                         | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-------|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7:0   | Error count                  | This is a 64-bit incrementing error count, indicating a unique identifier for this error. The error count starts at 1h, is incremented for each unique error log entry, and is retained across power off conditions. A value of 0h indicates an invalid entry; this value may be used when there are lost entries or when there are fewer errors than the maximum number of entries the controller supports.                                                                                                               |
| 9:8   | Submission queue ID          | This field indicates the submission queue Identifier of the command that the error information is associated with. If the error is not specific to a particular command then this field shall be set to FFFFh.                                                                                                                                                                                                                                                                                                             |
| 11:10 | Command ID                   | This field indicates the command Identifier of the command that the error is associated with. If the error is not specific to a particular command then this field shall be set to FFFFh.                                                                                                                                                                                                                                                                                                                                  |
| 13:12 | Status field                 | This field indicates the status field for the command that completed. The status field is located in bits 15:01, bit 00 corresponds to the phase tag posted for the command. If the error is not specific to a particular command then this field reports the most applicable status value.                                                                                                                                                                                                                                |
| 15:14 | Parameter error location     | This field indicates the byte and bit of the command parameter that the error is associated with, if applicable. If the parameter spans multiple bytes or bits, then the location indicates the first byte and bit of the parameter.<br>Bit 7:0; Byte in command that contained the error. Valid values are 0 to 63.<br>Bit 10:8; Bit in command that contained the error. Valid values are 0 to 7.<br>Bit 15:11; Reserved.<br>If the error is not specific to a particular command then this field shall be set to FFFFh. |
| 23:16 | LBA                          | This field indicates the first LBA that experienced the error condition, if applicable.                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 27:24 | Namespace                    | This field indicates the namespace that the error is associated with, if applicable.                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 31:28 | Reserved                     | Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 39:32 | Command specific information | This field contains command specific information. If used, the command definition specifies the information returned.                                                                                                                                                                                                                                                                                                                                                                                                      |
| 63:40 | Reserved                     | Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |


**Table 26: SMART/Health Information (Log Identifier 02h)**

| Bytes  | Name                      | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0      | Critical warning          | <p>Indicates critical warnings for the state of the controller. Each bit corresponds to a critical warning type; multiple bits may be set. If a bit is cleared to 0, the critical warning does not apply. Critical warnings may result in an asynchronous event notification to the host.</p> <p>Bit 0; If set to 1, the available spare space has fallen below the threshold.</p> <p>Bit 1; If set to 1, the temperature has exceeded a critical threshold.</p> <p>Bit 2; If set to 1, the device reliability has been degraded due to significant media-related errors or any internal error that degrades device reliability.</p> <p>Bit 3; If set to 1, the media has been placed in read-only mode.</p> <p>Bit 4; If set to 1, the volatile memory backup device has failed.</p> <p>Bits 7:5; Reserved.</p> |
| 2:1    | Temperature               | Contains the temperature of the controller in units of Kelvin. If it exceeds the temperature threshold, an asynchronous event may be issued to the host.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 3      | Available spare           | Contains a normalized percentage (0–100%) of the remaining available spare capacity.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 4      | Available spare threshold | When the available spare falls below the threshold indicated in this field, an asynchronous event may be issued to the host. The value is indicated as a normalized percentage (0–100%).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 5      | Percentage used           | <p>Contains an estimate of the percentage of the device life used based on the actual device usage and prediction of device life. A value of 100 indicates that the estimated endurance of the device has been consumed, but may not indicate a device failure. The value is allowed to exceed 100.</p> <p>Percentages greater than 254 shall be represented as 255. This value shall be updated once per power-on hour (when the controller is not in a sleep state).</p>                                                                                                                                                                                                                                                                                                                                       |
| 31:6   | Reserved                  | Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 47:32  | Data units read           | Contains the number of 512-byte data units the host has read from the controller; this value does not include metadata. This value is reported in thousands (that is, a value of 1 corresponds to 1000 units of 512 bytes read) and is rounded up. For the NVM command set, logical blocks read as part of COMPARE and READ operations shall be included in this value.                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 63:48  | Data units written        | Contains the number of 512-byte data units the host has written to the controller; this value does not include metadata. This value is reported in thousands (that is, a value of 1 corresponds to 1000 units of 512 bytes written) and is rounded up. For the NVM command set, logical blocks written as part of WRITE operations shall be included in this value.                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 79:64  | Host READ commands        | Contains the number of READ commands completed by the controller. For the NVM command set, this is the number of COMPARE and READ commands.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 95:80  | Host WRITE commands       | Contains the number of WRITE commands completed by the controller. For the NVM command set, this is the number of WRITE commands.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 111:96 | Controller busy time      | Contains the amount of time the controller is busy with I/O commands. The controller is busy when there is a command outstanding to an I/O queue (specifically, a command was issued via an I/O submission queue tail doorbell write and the corresponding completion queue entry has not been posted yet to the associated I/O completion queue. This value is reported in minutes.                                                                                                                                                                                                                                                                                                                                                                                                                             |


**Table 26: SMART/Health Information (Log Identifier 02h) (Continued)**

| Bytes   | Name                                              | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------|---------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 127:112 | Power cycles                                      | Contains the number of power cycles.                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 143:128 | Power on hours                                    | Contains the number of power-on hours. This does not include time that the controller was powered and in a low-power state condition.                                                                                                                                                                                                                                                                                                                        |
| 159:144 | Unsafe shutdowns                                  | Contains the number of unsafe shutdowns. This count is incremented when a shutdown notification (CC.SHN) is not received prior to loss of power.                                                                                                                                                                                                                                                                                                             |
| 175:160 | Media and data integrity errors                   | Contains the number of occurrences where the controller detected an unrecovered data integrity error.                                                                                                                                                                                                                                                                                                                                                        |
| 191:176 | Number of error info log entries                  | Contains the number of error information log entries over the life of the controller.                                                                                                                                                                                                                                                                                                                                                                        |
| 195:192 | Warning composite temperature time                | Contains the amount of time in minutes that the controller is operational and the composite temperature is greater than or equal to the warning composite temperature threshold (WCTEMP) field and less than the critical composite temperature threshold (CCTEMP) field in the Identify controller data structure. If the value of the WCTEMP or CCTEMP field is 0h, then this field is always cleared to 0h regardless of the composite temperature value. |
| 199:196 | Critical composite temperature time               | Contains the amount of time in minutes that the controller is operational and the composite temperature is greater the critical composite temperature threshold (CCTEMP) field in the Identify controller data structure. If the value of the CCTEMP field is 0h, then this field is always cleared to 0h regardless of the composite temperature value.                                                                                                     |
| 201:200 | Temperature Sensor 1                              | Contains the highest Nand temperature.                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 215:202 | Reserved                                          | Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 219:216 | Thermal Management Temperature 1 transition count | Contains the number of times the controller transitioned to lower power active power states or performed vendor-specific thermal management actions while minimizing the impact on performance in order to attempt to reduce the Composite Temperature because of the host-controlled thermal management feature. This counter shall not wrap after it reaches its maximum value. A value of zero indicates that this transition has never occurred.         |
| 223:220 | Thermal Management Temperature 2 transition count | Contains the number of times the controller transitioned to lower power active power states or performed vendor-specific thermal management actions regardless of the impact on performance in order to attempt to reduce the Composite Temperature because of the host-controlled thermal management feature. This counter shall not wrap after it reaches its maximum value. A value of zero indicates that this transition has never occurred.            |
| 227:224 | Total time for Thermal Management Temperature 1   | Contains the number of seconds that the controller transitioned to lower power active power states or performed vendor-specific thermal management actions while minimizing the impact on performance in order to attempt to reduce the Composite Temperature because of the host-controlled thermal management feature. This counter shall not wrap after it reaches its maximum value. A value of zero indicates that this transition has never occurred.  |


**Table 26: SMART/Health Information (Log Identifier 02h) (Continued)**

| Bytes   | Name                                            | Description                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 231:228 | Total time for Thermal Management Temperature 2 | Contains the number of seconds that the controller transitioned to lower power active power states or performed vendor-specific thermal management actions regardless of the impact on performance in order to attempt to reduce the Composite Temperature because of the host controlled thermal management feature. This counter shall not wrap after it reaches its maximum value. A value of zero indicates that this transition has never occurred. |
| 511:232 | Reserved                                        | Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

**Table 27: Firmware Slot Information (Log Identifier 03h)**

| Bytes  | Name                                | Description                                                                                                                                                                                                                                                                                                     |
|--------|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0      | Active Firmware Info (AFI)          | Specifies information about the active firmware revision.<br>Bit 7 is reserved.<br>Bits 6:4 indicates the firmware slot that is going to be activated at the next controller reset.<br>Bit 3 is reserved.<br>Bits 2:0 indicates the firmware slot from which the actively running firmware revision was loaded. |
| 7:1    | Reserved                            | Reserved                                                                                                                                                                                                                                                                                                        |
| 15:08  | Firmware Revision for Slot 1 (FRS1) | Contains the revision of the firmware downloaded to firmware slot 1.                                                                                                                                                                                                                                            |
| 511:16 | Reserved                            | Reserved                                                                                                                                                                                                                                                                                                        |

**Table 28: Commands Supported and Effects (Log Identifier 05h)**

| Bytes     | Name                                 | Description                                                                                                                                                         |
|-----------|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3:0       | Admin Command Supported 0 (ACS0)     | Contains the Command Effect data structure for the Admin command with an opcode value of 0h. The format of this field is defined by the NVM Express specification.  |
| ...       | ...                                  | ...                                                                                                                                                                 |
| 1023:1020 | Admin Command Supported 255 (ACS255) | Contains the Command Effect data structure for the Admin command with an opcode value of 255. The format of this field is defined by the NVM Express specification. |
| 1027:1024 | I/O Command Supported 0 (IOCS0)      | Contains the Command Effect data structure for the I/O command with an opcode value of 0h. The format of this field is defined by the NVM Express specification.    |
| ...       | ...                                  | ...                                                                                                                                                                 |
| 2047:2044 | I/O Command Supported 255 (IOCS255)  | Contains the Command Effect data structure for the I/O command with an opcode value of 255. The format of this field is defined by the NVM Express specification.   |
| 4095:2048 | Reserved                             | Reserved                                                                                                                                                            |




**Table 29: Device Self-Test Log (Log Identifier 06h)**

| Bytes   | Name                                               | Description                                                                                                                                                                                                                                                                                                                                                                |
|---------|----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0       | Current Device Self-Test Operation                 | Defines the current device self-test operation.<br>Bits 7:4 are reserved.<br>Bits 3:0 Value indicates the status of the current device self-test operation.<br>Value 0h = No device self-test operation in progress.<br>Value 1h = Short device self-test operation in progress.<br>Value 2h = Extended device self-test operation in progress.<br>Value Fh:3h = Reserved. |
| 1       | Current Device Self-Test Completion                | Defines the completion status of the current device self-test.<br>Bit 7 is reserved.<br>Bits 6:0 indicates the percentage of the device self-test operation that is complete.                                                                                                                                                                                              |
| 3:2     | Reserved                                           | Reserved                                                                                                                                                                                                                                                                                                                                                                   |
| 31:4    | Newest Device Self-Test Result Data Structure      | The format of this field is defined by the NVM Express specification.                                                                                                                                                                                                                                                                                                      |
| ...     | ...                                                | ...                                                                                                                                                                                                                                                                                                                                                                        |
| 563:536 | 20th Newest Device Self-Test Result Data Structure | The format of this field is defined by the NVM Express specification.                                                                                                                                                                                                                                                                                                      |



## TCG/Opal Support

**Table 30: TCG/Opal Support Parameters**

| Property                                             | Supported?                  | Comments                                                                                                                                     |
|------------------------------------------------------|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| <b>TCG Storage Specifications</b>                    |                             |                                                                                                                                              |
| OPAL: TCG Storage Security SubSystem Class           | Specification 2.00          | Revision 1.00, Feb 24, 2012                                                                                                                  |
| TCG Core Specification                               | Specification 2.00          | Revision 2.00, Nov 4, 2011                                                                                                                   |
| TCG Storage Interface Interactions Specification     | TCG Reference Specification | Specification Version 1.02 Revision 1.00 30 December, 2011                                                                                   |
| OPAL SSC 1.00 (backward compatibility)               | Not supported               | –                                                                                                                                            |
| <b>OPAL SSC Additional Feature Set Specification</b> |                             |                                                                                                                                              |
| Additional DataStore Table                           | Supported                   | Specification 1.00 Revision 1.00, Feb 24, 2012                                                                                               |
| Single User Mode                                     | Supported                   | Specification 1.00 Revision 1.00, Feb 24, 2012                                                                                               |
| TCG Storage Protection Mechanisms for Secrets        | Supported                   | Specification Version 1.00 Revision 1.07 17 August, 2011                                                                                     |
| PSID – Physical Presence SID                         | Supported                   | Specification Version 1.00 Committee Draft Revision 1.05 February 9, 2011                                                                    |
| GUDID (Globally Unique Serial Number)                | Supported                   | Mandatory GUDID Proposal 11/03/2011 (Microsoft)                                                                                              |
| SID Authority Disable                                | Supported                   | SID Authority Disable Proposal 9/26/2011 (Microsoft)                                                                                         |
| Modifiable CommonName Columns                        | Supported                   | Modifiable CommonName Columns Proposal 7/22/2010 (Microsoft)                                                                                 |
| <b>OPAL SSC Feature Set – Specific List</b>          |                             |                                                                                                                                              |
| ALL OPAL Mandatory Features                          | Supported                   | –                                                                                                                                            |
| Close Session (optional)                             | Supported                   | Allows Tper to notify the host it has aborted a session                                                                                      |
| Restricted Command & Table (optional)                | Not Supported               | The interface control template enables TPer control over selected interface commands; the benefit is the reduction of undesired side effects |
| Type Table (not required)                            | Not Supported               | –                                                                                                                                            |
| Activate Method                                      | Supported                   | –                                                                                                                                            |
| Revert Method                                        | Supported                   | –                                                                                                                                            |
| Revert SP Method                                     | Supported                   | –                                                                                                                                            |
| Activate Method Within Transactions                  | Not Supported               | As per OPAL, this behavior is out of the scope                                                                                               |
| Revert Method within Transactions                    | Not Supported               | As per OPAL, this behavior is out of the scope                                                                                               |
| Revert SP Method within Transactions                 | Not Supported               | As per OPAL, this behavior is out of the scope                                                                                               |
| Creation/Deletion of Tables/Rows after Manufacturing | Not Supported               | As per OPAL, this behavior is out of the scope                                                                                               |
| <b>Tper Feature</b>                                  |                             |                                                                                                                                              |
| COM ID Management Support                            | Not Supported               | Dynamic COM ID allocation & management not supported                                                                                         |
| Buffer Management Support                            | Not Supported               | Flow control                                                                                                                                 |


**Table 30: TCG/Opal Support Parameters (Continued)**

| Property                                         | Supported?    | Comments                                                                                                                                                                                                                                                                                                                                                                |
|--------------------------------------------------|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ACK/NACK Support                                 | Not Supported | Session reliability                                                                                                                                                                                                                                                                                                                                                     |
| Async Support                                    | Not Supported | Asynchronous protocol support with multiple commands per session                                                                                                                                                                                                                                                                                                        |
| <b>Geometry Reporting Feature</b>                |               |                                                                                                                                                                                                                                                                                                                                                                         |
| ALIGN                                            | Supported     | OPAL 2.0 (only)                                                                                                                                                                                                                                                                                                                                                         |
| Logical Block Size                               | 512 bytes     | Logical block size = 512 Bytes                                                                                                                                                                                                                                                                                                                                          |
| Alignment Granularity                            | 4096 Bytes    | Page or Descriptor size <<Minimum AES LU size>>                                                                                                                                                                                                                                                                                                                         |
| Lowest Aligned LBA                               | 0             | –                                                                                                                                                                                                                                                                                                                                                                       |
| <b>OPAL SSC V2.00 Feature Descriptor</b>         |               |                                                                                                                                                                                                                                                                                                                                                                         |
| Base COM ID                                      | 0x1000        | 0x1000-0xFFFF defined for COM ID management                                                                                                                                                                                                                                                                                                                             |
| Number of COM IDs                                | 1             | –                                                                                                                                                                                                                                                                                                                                                                       |
| Range Crossing Behavior                          | 0             | If drive receives a READ or WRITE command that spans multiple LBA ranges and the LBA ranges are not locked, then:<br>1. Process the data transfer, if Range Crossing = 0<br>2. Terminate the command with "Other Invalid Command Parameter" if Range Crossing = 1                                                                                                       |
| Number of Locking SP Admin Authorities Supported | 4             | As per OPAL 2.0, drive should support at least 4 admin                                                                                                                                                                                                                                                                                                                  |
| Number of Locking SP User Authorities Supported  | 16            | As per OPAL 2.0, drive should support at least 8 users                                                                                                                                                                                                                                                                                                                  |
| Initial C_PIN_SID PIN Indicator                  | 0x00          | 0x00 = The initial C_PIN_SID PIN value is equal to the C_PIN_MSID PIN value<br>0xFF = The initial C_PIN_SID PIN value is VU, and MAY not be equal to the C_PIN_MSID PIN value<br>OPAL 2.0 (only)<br>Customer-specific SID – Configurable                                                                                                                                |
| Behavior of C_PIN_SID PIN upon Ter Revert        | 0x00          | 0x00 = The C_PIN_SID PIN value becomes the value of the C_PIN_MSID PIN column after successful invocation of revert on the admin SP's object in the SP table<br>0xFF = The C_PIN_SID PIN value changes to a VU value after successful invocation of revert on the admin SP's object in the SP table and MAY not be equal to the C_PIN_MSID PIN value<br>OPAL 2.0 (only) |
| <b>DataStore Table Feature</b>                   |               |                                                                                                                                                                                                                                                                                                                                                                         |
| Maximum number of DataStore Tables               | 16            | The maximum number of the DataStore tables that the TPer supports, including the DataStore table defined in OPAL SSC 2.0                                                                                                                                                                                                                                                |
| Maximum total size of DataStore Tables           | 90MB          | Specifies the maximum total size in bytes of all of the DataStore tables that TPer supports, including the DataStore table defined in OPAL SSC 2.0                                                                                                                                                                                                                      |
| MBR Table                                        | 128MB         | –                                                                                                                                                                                                                                                                                                                                                                       |


**Table 30: TCG/Opal Support Parameters (Continued)**

| Property                                           | Supported?                                   | Comments                                                                                                                                                                                       |
|----------------------------------------------------|----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Byte Table Access Granularity</b>               |                                              |                                                                                                                                                                                                |
| Mandatory Write Granularity                        | 1                                            | TPer enforces when the host invokes the set method on byte tables; it should be less than or equal to 8192; it should be less than or equal to Recommended Access Granularity, OPAL 2.0 (only) |
| Recommended Access Granularity                     | 8192                                         | Tper recommends when the host invokes the set or get method on byte tables; it should be less than or equal to 8192                                                                            |
| <b>Cryptographic Features</b>                      |                                              |                                                                                                                                                                                                |
| AES Key Size                                       | 256 Bits                                     | AES key is generated by using CTR DRBG algorithm (FIPS Compliant)                                                                                                                              |
| AES Mode                                           | CBC                                          | IV swapped                                                                                                                                                                                     |
| Number of Ranges/Band Supported                    | 16<br>(15 user definable,<br>1 global range) | Now supporting 15 LBA ranges; range cross read and write allowed if LBA ranges are unlocked                                                                                                    |
| Re-Encryption                                      | Not Supported                                | –                                                                                                                                                                                              |
| Key Management                                     |                                              | Cryptographic                                                                                                                                                                                  |
| Crypto Erase Completion Time <1s                   | Yes                                          | –                                                                                                                                                                                              |
| Cryptographic Algorithms are Certified by FIPS-197 | No                                           | Designed to meet, no plans for certification                                                                                                                                                   |
| AES 256-Bit CBC/ECB Mode                           | Supported                                    | ECB mode used only for generating the random key by CTR DRBG                                                                                                                                   |
| CTR DRBG                                           | Supported                                    | –                                                                                                                                                                                              |
| SHA 256                                            | Supported                                    | –                                                                                                                                                                                              |
| RSA 2048 Signature Verification                    | Supported                                    | –                                                                                                                                                                                              |
| <b>TPer Communication Properties</b>               |                                              |                                                                                                                                                                                                |
| Max ComPacket Size                                 | 32256                                        | in Byte                                                                                                                                                                                        |
| Max Response ComPacket Size                        | 32256                                        | in Byte                                                                                                                                                                                        |
| Max Packet Size                                    | 32236                                        | in Byte                                                                                                                                                                                        |
| Max Individual Token Size                          | 32200                                        | in Byte                                                                                                                                                                                        |
| Max Packets                                        | 1                                            | –                                                                                                                                                                                              |
| Max SubPackets                                     | 1                                            | –                                                                                                                                                                                              |
| Max Sessions                                       | 1                                            | Each session requires a set of buffers and variables                                                                                                                                           |
| Max Transaction Limit                              | 1                                            | Transaction are inside sessions                                                                                                                                                                |
| Max Methods                                        | 1                                            | Methods are contained in a transaction                                                                                                                                                         |
| Max Authentications                                | 14                                           | –                                                                                                                                                                                              |
| Def Session Timeout                                | Yes                                          | The session timeout length (in milliseconds) used by the TPer by default                                                                                                                       |
| <b>IEEE1667</b>                                    |                                              |                                                                                                                                                                                                |
| Probe Silo                                         | Supported                                    | –                                                                                                                                                                                              |


**Table 30: TCG/Opal Support Parameters (Continued)**

| Property                               | Supported?    | Comments                                                          |
|----------------------------------------|---------------|-------------------------------------------------------------------|
| TCG Storage Silo                       | Supported     | –                                                                 |
| Other than Probe and TCG Storage Silo  | Not Supported | –                                                                 |
| IEEE1667 Major Version                 | 2             | –                                                                 |
| IEEE1667 Minor Version                 | 0             | –                                                                 |
| Maximum P_OUT Transfer Size            | 32768         | 256 sectors (128K)                                                |
| <b>Others</b>                          |               |                                                                   |
| FDE (ATA Security with Key Management) | Yes           | –                                                                 |
| Secure Firmware Download               | Supported     | Firmware image is validated by using SHA256 and RSA2048 algorithm |





## PCI Header

**Table 31: PCI Header Space Registers**

| Start Address | End Address | Symbols | Register Definition | Bits  | Type  | Default Value | Description                           |
|---------------|-------------|---------|---------------------|-------|-------|---------------|---------------------------------------|
| 00h           | 03h         | ID      | Identifiers         | 31:16 | RO    | 6001h         | Device ID (DID)                       |
|               |             |         |                     | 0:15  | RO    | 1344h         | Vendor ID (VID)                       |
| 04h           | 05h         | CMD     | Command Register    | 15:11 | RO    | 0             | Reserved                              |
|               |             |         |                     | 10    | RW    | 0             | Interrupt Disable                     |
|               |             |         |                     | 9     | RO    | 0             | Fast Back-to-Back Enable              |
|               |             |         |                     | 8     | RW    | 0             | SERR# Enable                          |
|               |             |         |                     | 7     | RO    | 0             | IDSEL Stepping/Wait Cycle Control     |
|               |             |         |                     | 6     | RW    | 0             | Parity Error Response Enable          |
|               |             |         |                     | 5     | RO    | 0             | VGA Palette Snooping Enable           |
|               |             |         |                     | 4     | RO    | 0             | Memory Write and Invalidate Enable    |
|               |             |         |                     | 3     | RO    | 0             | Special Cycle Enable                  |
|               |             |         |                     | 2     | RW    | 0             | Bus Master Enable                     |
|               |             |         |                     | 1     | RW    | 0             | Memory Space Enable                   |
|               |             |         |                     | 0     | RW    | 0             | I/O Space Enable                      |
| 06h           | 07h         | STS     | Device Status       | 15    | RW1 C | 0             | Detected Parity Error                 |
|               |             |         |                     | 14    | RW1 C | 0             | Signaled System Error                 |
|               |             |         |                     | 13    | RW1 C | 0             | Received Master Abort                 |
|               |             |         |                     | 12    | RW1 C | 0             | Received Target Abort                 |
|               |             |         |                     | 11    | RW1 C | 0             | Signaled Target Abort                 |
|               |             |         |                     | 10:9  | RO    | 0             | DEVSEL Timing                         |
|               |             |         |                     | 7     | RO    | 0             | Master Data Parity Error Detected     |
|               |             |         |                     | 8     | RW1 C | 0             | Fast Back-to-Back Transaction Capable |
|               |             |         |                     | 6     | RO    | 0             | Reserved                              |
|               |             |         |                     | 5     | RO    | 0             | 66MHz Capable                         |
|               |             |         |                     | 4     | RO    | 0             | Capabilities List                     |
|               |             |         |                     | 3     | RO    | 0             | Interrupt Status                      |
|               |             |         |                     | 2:1   | RO    | 0             | Reserved                              |
|               |             |         |                     | 0     | RO    | 0             | Reserved                              |
| 08h           | 08h         | RID     | Revision ID         | 7:10  | RO    | 0             | Controller Hardware Revision ID       |


**Table 31: PCI Header Space Registers (Continued)**

| Start Address | End Address | Symbols      | Register Definition                         | Bits  | Type | Default Value   | Description                    |
|---------------|-------------|--------------|---------------------------------------------|-------|------|-----------------|--------------------------------|
| 09h           | 0Bh         | CC           | Class Codes                                 | 23:16 | RO   | 1h              | Base Class Code                |
|               |             |              |                                             | 15:8  | RO   | 8h              | Sub Class Code                 |
|               |             |              |                                             | 7:0   | RO   | 2h              | Programming Interface          |
| 0Ch           | 0Ch         | CLS          | Cache Line Size                             | 7:0   | RO   | 0               | N/A                            |
| 0Dh           | 0Dh         | MLT          | Master Latency Timer                        | 7:0   | RO   | 0               | N/A                            |
| 0Eh           | 0Eh         | HTYPE        | Header Type                                 | 7     | RO   | 0               | Multi-Function Device          |
|               |             |              |                                             | 6:0   | RO   | 0               | Reserved                       |
| 0Fh           | 0Fh         | BIST         | Built in Self Test                          | 7:0   | RO   | 0               | Not Supported                  |
| 10h           | 13h         | MLBAR (BAR0) | Memory Register Base Address (lower 32-bit) | 31:14 | RW   | 0               | Base Address                   |
|               |             |              |                                             | 13:4  | RO   | 0               | Reserved                       |
|               |             |              |                                             | 3     | RO   | 0               | Pre-Fetchable                  |
|               |             |              |                                             | 2:1   | RO   | 2h              | Address Type (64-bit)          |
|               |             |              |                                             | 0     | RO   | 0               | Memory Space Indicator (MEMSI) |
| 14h           | 17h         | MUBAR (BAR1) | Memory Register Base Address (upper 32-bit) | 31:0  | RO   | 0               | Base Address                   |
| 18h           | 1Bh         | IDBAR (BAR2) | Index/Data Pair Register Base Address       | 31:0  | RO   | 0               | Not Supported                  |
| 1Ch           | 1Fh         | BAR3         | BAR3 Register                               | 31:0  | RO   | 0               | Reserved                       |
| 20h           | 23h         | BAR4         | BAR4 Register                               | 31:0  | RO   | 0               | Vendor Specific                |
| 24h           | 27h         | BAR5         | Vendor Specific BAR5                        | 31:0  | RO   | 0               | Vendor Specific                |
| 28h           | 2Bh         | CCPTR        | CardBus CIS Pointer                         | 31:0  | RO   | 0               | N/A                            |
| 2Ch           | 2Fh         | SS           | Subsystem Identifiers                       | 31:16 | RO   | See table below | Subsystem ID (SSID)            |
|               |             |              |                                             | 15:0  | RO   | 1344h           | Subsystem Vendor ID (SSVID)    |
| 30h           | 33h         | EXPROM       | Expansion ROM Base Address                  | 31:17 | RW   | 0               | Expansion ROM Base Address     |
|               |             |              |                                             | 16:1  | RO   | 0               | Reserved                       |
|               |             |              |                                             | 0     | RW   | 0               | Expansion ROM Enable/Disable   |
| 34h           | 34h         | CAP          | Capabilities Pointer                        | 7:0   | RO   | 0               | N/A                            |
| 35h           | 3Bh         | R            | Reserved                                    |       |      |                 |                                |
| 3Ch           | 3Dh         | INTR         | Interrupt Information                       | 15:8  | RO   | 01h             | Interrupt Pin                  |
|               |             |              |                                             | 7:0   | RW   | FFh             | Interrupt Line                 |
| 3Eh           | 3Eh         | MGNT         | Minimum Grant                               | 7:0   | RO   | 0               | N/A                            |
| 3Fh           | 3Fh         | MLAT         | Maximum Latency                             | 7:0   | RO   | 0               | N/A                            |


**64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD  
PCI Header**
**Table 32: Subsystem ID (SSID)**

| Package | Density (GB) | Value |
|---------|--------------|-------|
| BGA     | 64           | 0400h |
|         | 128          | 0400h |
|         | 256          | 0400h |
|         | 512          | 1400h |
|         | 1024         | 2400h |
| M.2     | 128          | 0100h |
|         | 256          | 0100h |
|         | 512          | 1100h |
|         | 1024         | 2100h |

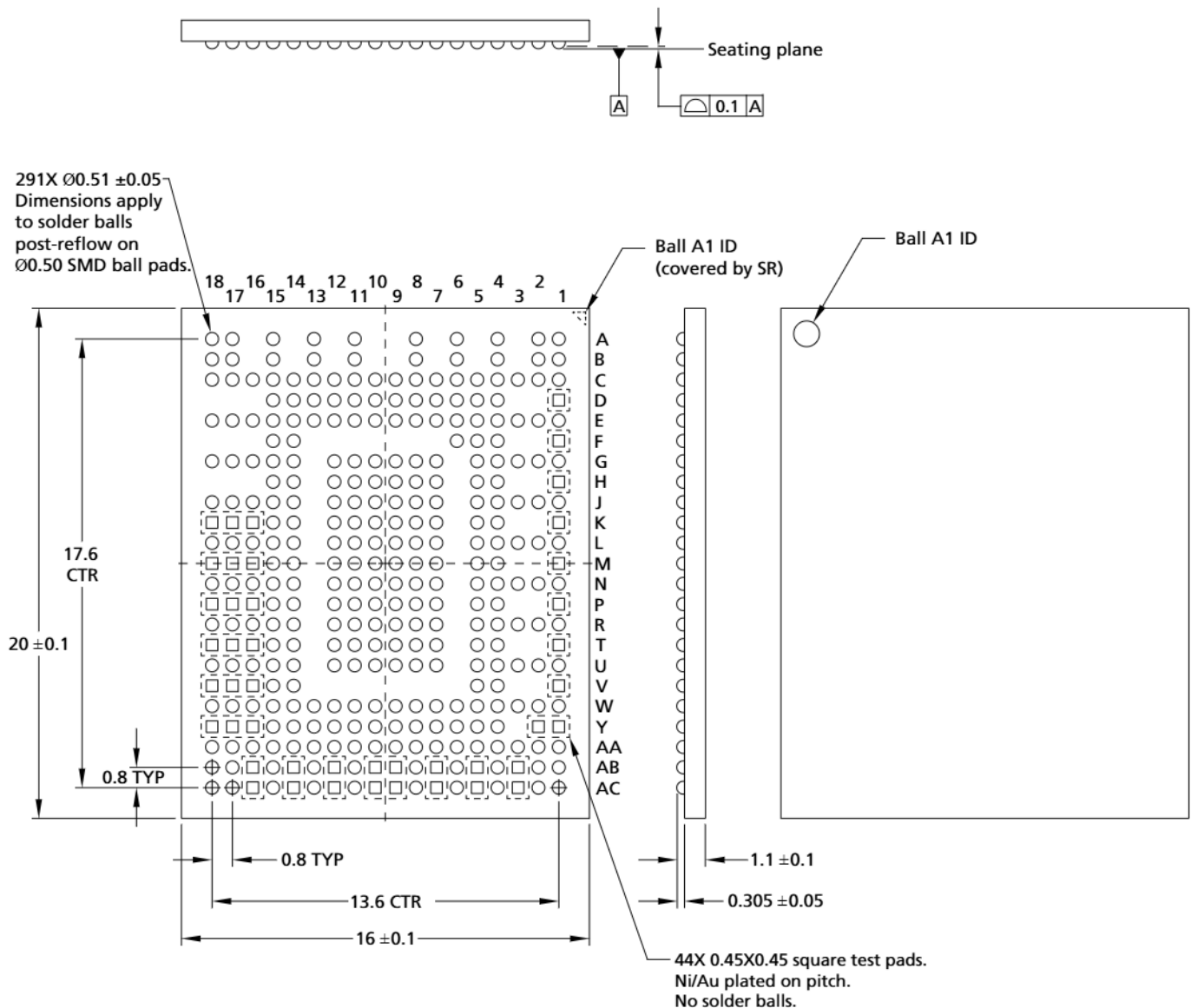


## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Package Physical Configuration

### Package Physical Configuration

#### BGA Type 1620

Figure 5: BGA Type 1620 – 291-Ball 16mm x 20mm x 1.2mm (Package Code BL)

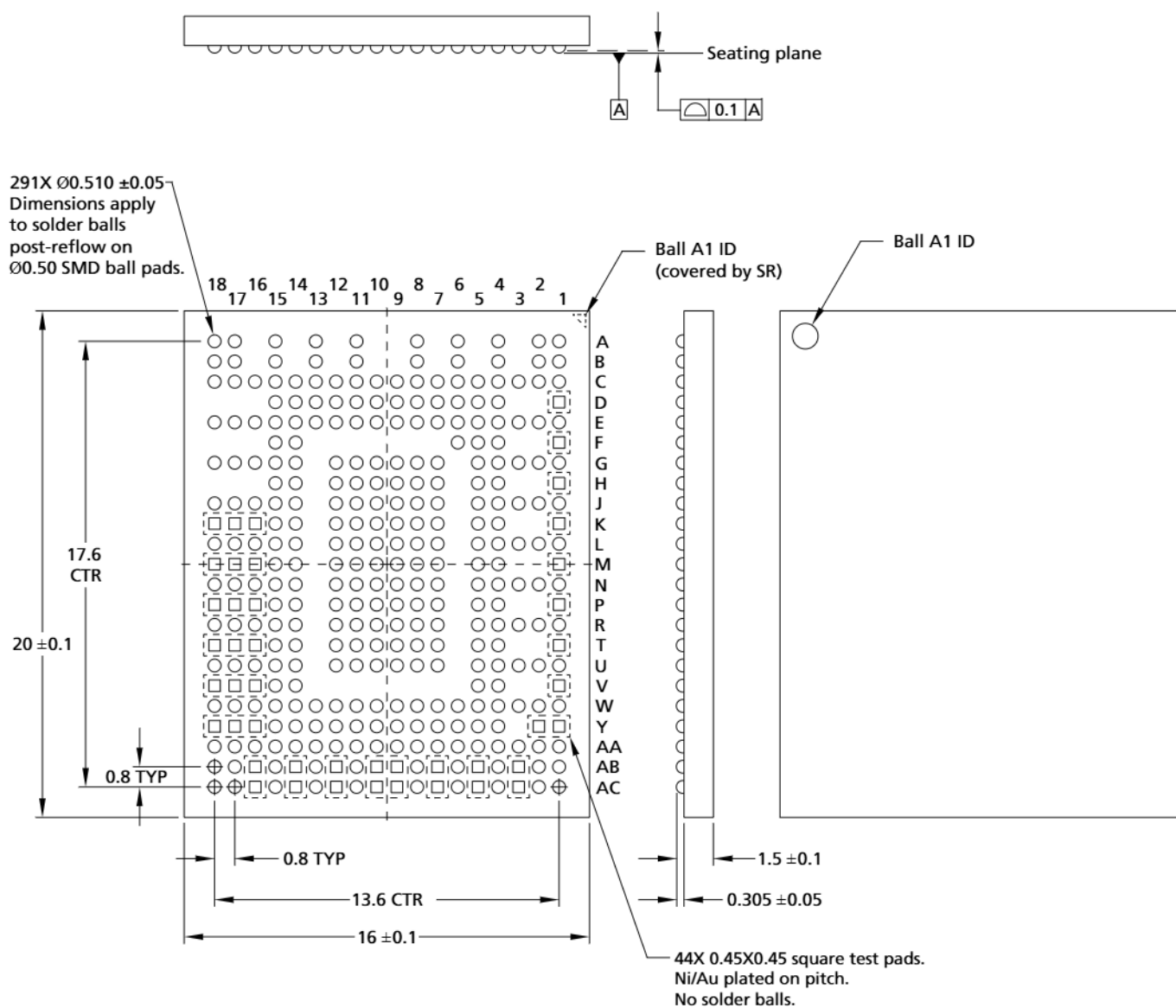


- Notes:
1. All dimensions are in millimeters.
  2. Ball diameter before soldering is 0.45mm. The solder ball composition is SAC405.
  3. For optimal Solder Join Reliability (SJR) performance refer to CSN33 for recommended PCB pad dimension to align to the SMD ball pad size of the package.



# 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Package Physical Configuration

**Figure 6: BGA Type 1620 – 291-Ball 16mm x 20mm x 1.6mm (Package Code BM)**



- Notes:
1. All dimensions are in millimeters.
  2. Ball diameter before soldering is 0.45mm. The solder ball composition is SAC405.
  3. For optimal Solder Join Reliability (SJR) performance refer to CSN33 for recommended PCB pad dimension to align to the SMD ball pad size of the package.

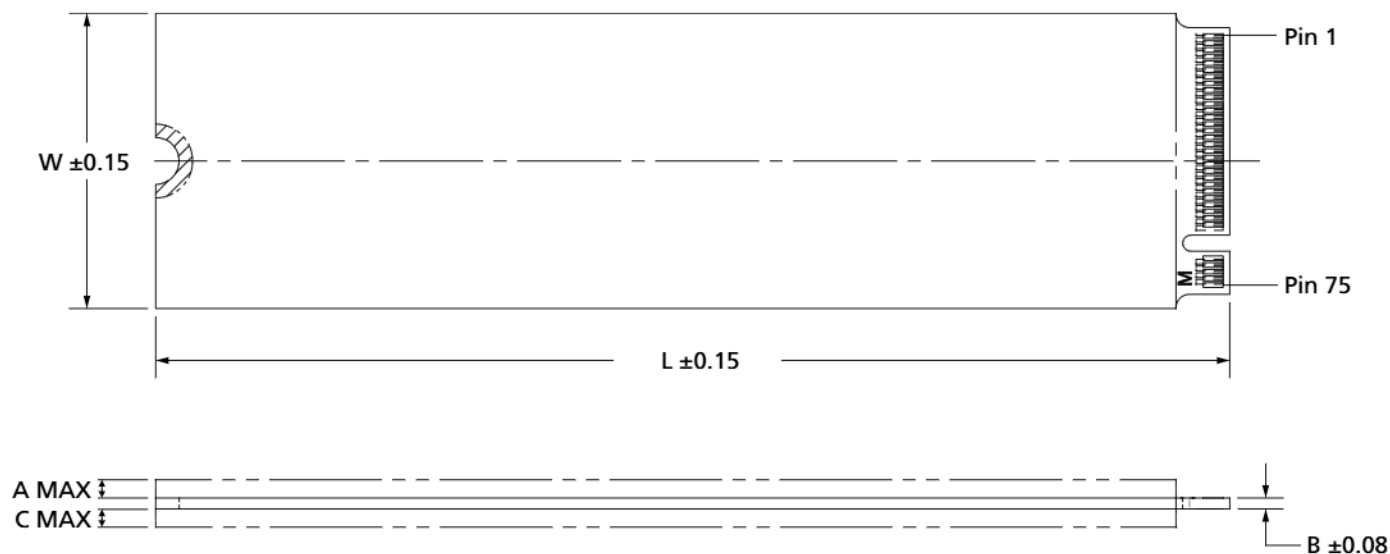




## Modules Physical Configuration

### M.2 Type 2230 (M-key)

**Figure 7: M.2 Type 2230 Form Factor (Package Code BK)**



Note: 1. All dimensions are in millimeters.

**Table 33: M.2 Type 2230 Form Factor Dimensions**

| Capacity    | Type | W     | L     | A   | B   | C   | Unit |
|-------------|------|-------|-------|-----|-----|-----|------|
| up to 512GB | 2230 | 22.00 | 30.00 | 1.2 | 0.8 | 0.0 | mm   |
| 1TB         | 2230 | 22.00 | 30.00 | 1.6 | 0.8 | 0.0 | mm   |



## Compliance (M.2 only)

The SSDs into M.2 package comply with the following:

- Micron Green Standard
- CE (Europe): EN55032, EN55024 Class B, RoHS
- FCC: CFR Title 47, Part 15, Class B, CNS 15663
- UL/cUL: approval to UL-60950-1, 2nd Edition, IEC 60950-1:2005 (2nd Edition); EN 60950-1 (2006) + A11:2009 + A1:2010 + A12:2011 + A2:2013
- BSMI (Taiwan): approval to CNS 13438 Class B
- RCM (Australia, New Zealand): AS/NZS CISPR32 Class B
- KC RRL (Korea): approval to KN32 Class B, KN 35 Class B

B 급 기기                      이 기기는 가정용으로 전자파적합등록을 한 기기로서 주거  
(가정용 정보통신기기)    지역에서는 물론 모든 지역에서 사용할 수 있습니다.

- W.E.E.E.: Compliance with EU WEEE directive 2012/19/EC. Additional obligations may apply to customers who place these products in the markets where WEEE is enforced.
- TUV (Germany): approval to IEC60950/EN60950
- VCCI (Japan): 2015-04 Class B

この装置は、クラス B 情報技術装置です。この装置は、家庭環境で使用することを目的としていますが、この装置がラジオやテレビジョン受信機に近接して使用されると、受信障害を引き起こすことがあります。

取扱説明書に従って正しい取り扱いをして下さい。

VCCI-B

- IC (Canada): ICES-003 Class B
  - This Class B digital apparatus complies with Canadian ICES-003.
  - Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.
- Morocco: EN55032, EN55024 Class B

## FCC Rules

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.



## References

- NVM Express, Revision 1.3
- PCI Express Base Specification, Revision 3.0
- PCI Express Electromechanical Specification, PCI Express M.2 Specification Revision 1.1
- PCI-SIG Engineering Change Notice: Power Loss Notification Functions (Mar. 26, 2018)
- PCI-SIG Engineering Change Notice: 1.8V sideband, Power Loss Notification, USB 2.0, and higher power support (Nov. 28, 2018). To be considered for forward compatibility
- TCG Storage Architecture Core Specification Version 2.01 Revision 1.00
- TCG Storage Security Subsystem Class: Opal Specification Version 2.01 Revision 1.00
- TCG Storage Security Subsystem Class: Pyrite Specification Version 1.00 Revision 1.00
- IDEMA Standard LBA 1-03
- JEDEC Standard, Integrated Circuits Thermal Test Method Environmental Conditions JESD51-2A
- For further information like technical notes and white papers on automotive and industrial Micron SSD, periodically check [www.micron.com](http://www.micron.com)



## Revision History

### Rev. C - 05/20

- Updated Table: Operating Ratings
  - Changed PWR\_1 range for BGA
  - Specified "Ambient" for "Rate of temperature change" and "Non-operating temperature" for both BGA and M.2 form factor
- Updated Notes in Table: Maximum Current per Power Rail.
- Updated Table: BGA Signal Description. In-Band-Signals type are now specified if they are Input (I) or Output (O); CLKREQ# type changed from Input/Output (I/O) to Open Drain (OD)
- Added Table: Drive Performance With/Without HMB Enabled (SLC Mode=100%) – Fresh Out of Box
- Minor editorial changes

### Rev. B - 12/19

- Data Sheet maturity level changed from *Preliminary* to *Production*; *Preliminary* has been removed on the top right corner of each page
- Added 64GB Micron Part Number for BGA package
- Updated Table: BGA Signal Description. Note no.6 include PWR\_1 recommendation for future SSD (from 3.3V to 2.5V)
- Updated Table: M.2 Signal Assignments. Added LED\_1#, UART\_RX and UART\_TX
- MTTF updated to 3 million.
- Renamed Table: Maximum Ratings into Operating Ratings. Sensor temperature symbol changed
- Removed Table: Drive Performance With/Without HMB Enabled – Steady State. The server workload condition for performance calculation does not apply to 2100AI/AT SSD.

### Rev. A - 11/19

- Power domain for PLN#/PLA# is changed to 3.3V on BGA. Ensure design correctness for your board schematics. For further information search for *TN-FD-47 2100AI\_AT PCIe Schematics Reference Design* Technical Note at <http://www.micron.com>
- Added a new table for BGA: Maximum Current per Power Rail.
- Updated Section: Identify Controller Data Structure.
- Updated Table: Maximum Ratings.
- Updated Section: Commands.
- Updated Section: Log Pages.
- Updated Section: TCG/Opal Support.
- Updated Section: Identify – Identify Namespace Data Structure.
- Added Section: PCI Header.
- Updated Table: Drive Performance With/Without HMB Enabled – Fresh Out of Box.
- Updated Table: Drive Performance With/Without HMB Enabled – Steady State.



## 64GB, 128GB, 256GB, 512GB, 1TB: 2100AI SSD Revision History

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### Pre-Release 04/19

- All details subject to change

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This data sheet contains minimum and maximum limits specified over the power supply and temperature range set forth herein. Although considered final, these specifications are subject to change, as further product development and data characterization sometimes occur.